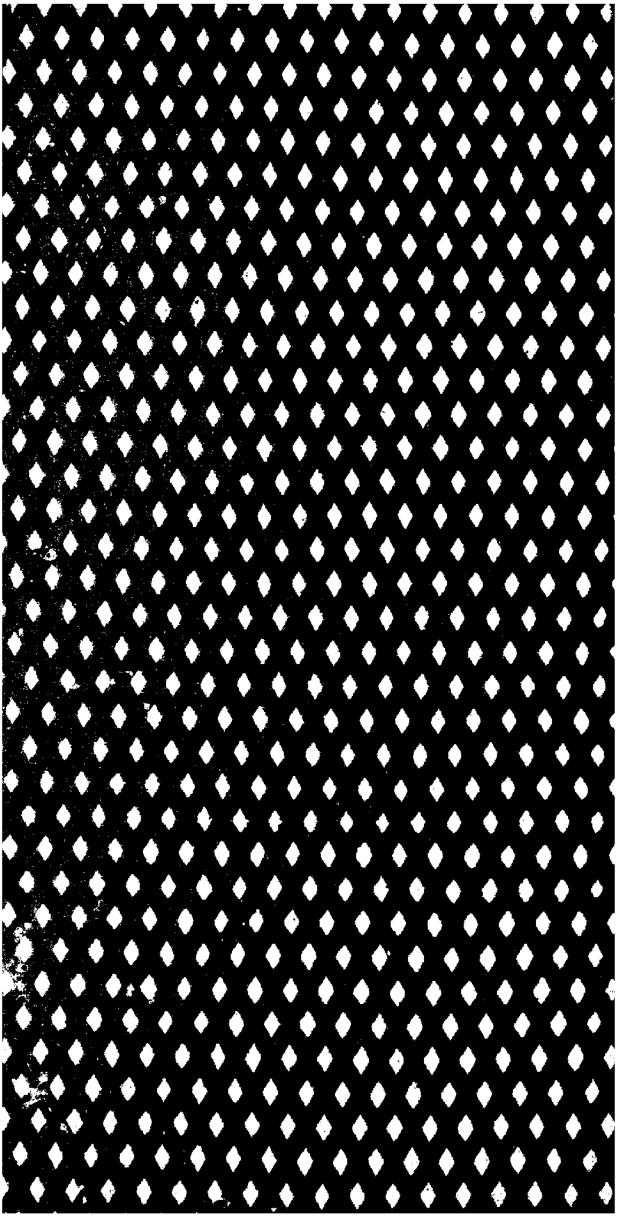

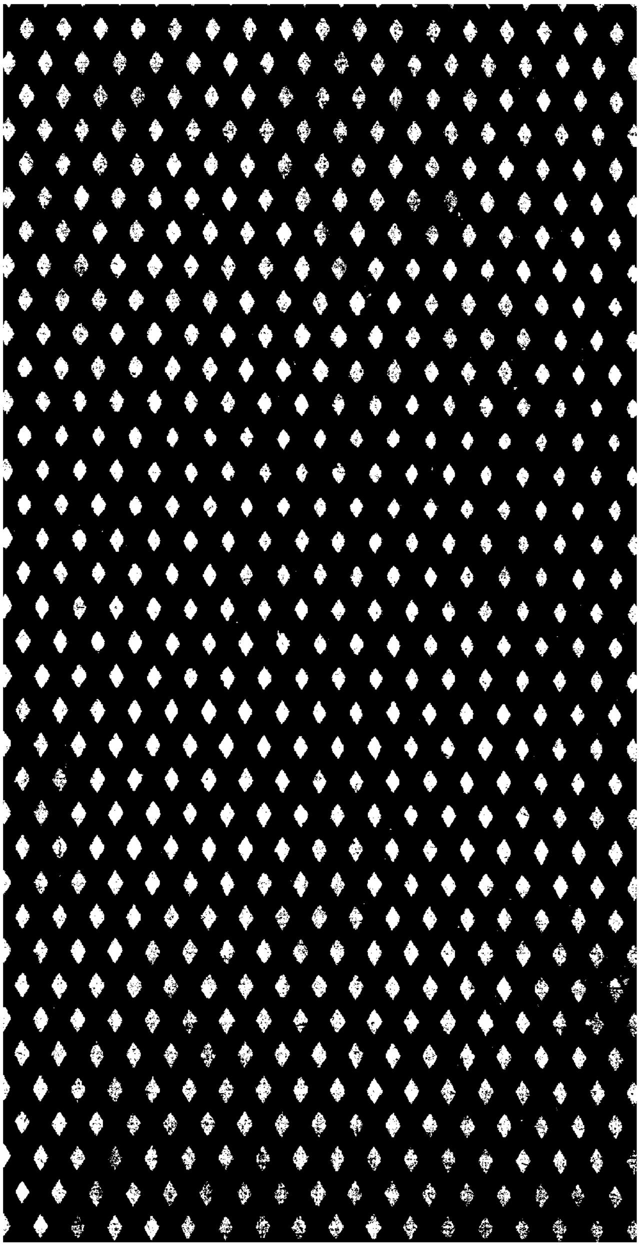

JOURNAL

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[1] Withdrawn for publication elsewhere.

Association of Economic Entomologists.

(Organized in 1889.)

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LIST OF MEETINGS AND PAST OFFICERS.

Officers and Meetings.

First Annual Meeting, Washington, D. C., Nov. 12–14, 1889. President, C. V. Riley; First Vice-President, S. A. Forbes; Second Vice-President, A. J. Cook; Secretary, John B. Smith.

Second Annual Meeting, Champaign, Ill., Nov. 11–13, 1890. (The same officers had charge of this meeting.)

Third Annual Meeting, Washington, D. C., Aug. 17–18, 1891. President, James Fletcher; First Vice-President, F. H. Snow; Second Vice-President, Herbert Osborn; Secretary, L. O. Howard.

Fourth Annual Meeting, Rochester, N. Y., Aug. 15–16, 1892. President, J. A. Lintner; First Vice-President, S. A. Forbes; Second Vice-President, J. H. Comstock; Secretary, F. M. Webster.

Fifth Annual Meeting, Madison, Wis., Aug. 14–16, 1893. President, S. A. Forbes; First Vice-President, C. J. S. Bethune; Second Vice-President, John B. Smith; Secretary, H. Garman.

Sixth Annual Meeting, Brooklyn, N. Y., Aug. 14–15, 1894. President, L. O. Howard; First Vice-President, John B. Smith; Second

Vice-President, F. L. Harvey; Secretary, C. P. Gillette.

Seventh Annual Meeting, Springfield, Mass., Aug. 27–28, 1895. President, John B. Smith; First Vice-President, C. H. Fernald; Secretary, C. L. Marlatt.

Eighth Annual Meeting, Buffalo, N. Y., Aug. 21–22, 1896. President, C. H. Fernald; First Vice-President, F. M. Webster; Second Vice-President, Herbert Osborn; Secretary, C. L. Marlatt.

Ninth Annual Meeting, Detroit, Mich., Aug. 12–13, 1897. President, F. M. Webster; First Vice-President, Herbert Osborn; Second Vice-President, Lawrence Bruner; Secretary, C. L. Marlatt.

Tenth Annual Meeting, Boston, Mass., Aug. 19–20, 1898. President, Herbert Osborn; First Vice-President, Lawrence Bruner; Second Vice President, C. P. Gillette; Secretary, C. L. Marlatt.

Eleventh Annual Meeting, Columbus, Ohio, Aug. 18–19, 1899. President, C. L. Marlatt; First Vice-President, Lawrence Bruner; Second Vice-President, C. P. Gillette; Secretary, A. H. Kirkland.

Twelfth Annual Meeting, New York, N. Y., June 22–23, 1900. President, Lawrence Bruner; First Vice-President, C. P. Gillette; Second Vice-President, E. H. Forbush; Secretary, A. H. Kirkland.

Thirteenth Annual Meeting, Denver, Colo., Aug. 23–24, 1901. President, C. P. Gillette; First Vice-President, A. D. Hopkins; Second Vice-President, E. P. Felt; Secretary, A. L. Quaintance.

Fourteenth Annual Meeting, Pittsburg, Pa., June 27–28, 1902. President, A. D. Hopkins; First Vice-President, E. P. Felt; Second Vice-President, T. D. A. Cockerell; Secretary, A. L. Quaintance.

Fifteenth Annual Meeting, Washington, D. C., Dec. 26–27, 1902. President, E. P. Felt; First Vice-President, W. H. Ashmead; Second Vice-President, Lawrence Bruner; Secretary, A. L. Quaintance.

Sixteenth Annual Meeting, St. Louis, Mo., Dec. 29–31, 1903. President, M. V. Slingerland; First Vice-President, C. M. Weed; Second Vice-President, Henry Skinner; Secretary, A. F. Burgess.

Seventeenth Annual Meeting, Philadelphia, Pa., Dec. 29–30, 1904. President, A. L. Quaintance; First Vice-President, A. F. Burgess; Second Vice-President, Mary E. Murtfeldt; Secretary, H. E. Summers.

Eighteenth Annual Meeting, New Orleans, La., Jan. 1–4, 1906. President, H. Garman; First Vice-President, E. D. Sanderson; Second Vice-President, F. L. Washburn; Secretary, H. F. Summers.

Nineteenth Annual Meeting, New York, N. Y., Dec. 28–29, 1906. President, A. H. Kirkland; First Vice-President, W. E. Britton; Second Vice-President, H. A. Morgan; Secretary, A. F. Burgess.

Twentieth Annual Meeting, Chicago, Ill., Dec. 27–28, 1907. President, H. A. Morgan; First Vice-President, H. E. Summers; Second Vice-President, W. D. Hunter; Secretary, A. F. Burgess.

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OFFICIAL ORGAN OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 1 FEBRUARY, 1908 No. 1

Proceedings of the Twentieth Annual Meeting of the Association of Economic Entomologists

The twentieth annual meeting of the Association of Economic Entomologists was held at the University of Chicago, Chicago, Illinois, December 27 and 28, 1907.

For convenience the report has been prepared in two parts, the first being devoted to the business transacted and the second containing the addresses, papers and discussions.

PART I

The meeting was called to order by President Morgan at 10 a. m., Friday, December 27, in Room 24, Zoölogy Building. The average number of members and visitors present during the meeting was ninety. The members attending were as follows:

C. E. Bartholomew, Ames, Iowa; G. M. Bentley, Knoxville, Tenn.; F. C. Bishopp, Washington, D. C.; W. E. Britton, New Haven, Conn.; F. E. Brooks, Morgantown, W. Va.; C. T. Brues, Milwaukee, Wis.; Lawrence Bruner, Lincoln, Neb.; A. F. Burgess, Washington, D. C.; R. S. Clifton, Washington, D. C.; Mel. T. Cook, Newark, Del.; E. C. Cotton, Knoxville, Tenn.; J. J. Davis, Urbana, Ill.; E. B. Engle, Harrisburg, Pa.; E. P. Felt, Albany, N. Y.; H. T. Fernald, Amherst, Mass.; James Fletcher, Ottawa, Canada; S. A. Forbes, Urbana, Ill.; G. H. French, Carbondale, Ill.; A. A. Girault, Urbana, Ill.; B. H. Guilbeau, Baton Rouge, La.; C. A. Hart, Urbana, Ill.; T. J Headlee, Manhattan, Kan.; W. E. Hinds, Auburn, Ala.; W. A. Hooker, Washington, D. C.; L. O. Howard, Washington, D. C.; W. D. Hunter, Washington, D. C.; Fred Johnson, Washington, D. C.; H. A. Morgan, Knoxville, Tenn.; Henry Ness, Ames, Iowa; Wilmon Newell, Baton Rouge, La.; J. F. Nicholson, Stillwater, Okla.; Herbert Osborn, Columbus, Ohio; Edith M. Patch, Orono, Me.; E. F. Phillips, Washington, D. C.; J. L. Phillips, Blacksburg, Va.; W. D. Pierce, Washington, D. C.; A. L. Quaintance, Washington, D. C.; W. A. Riley, Ithaca, N. Y.; A. G. Ruggles, St. Anthony Park, Minn.; W. E. Rumsey, Morgantown, W. Va.; J. G. Sanders, Washington, D. C.; E. D. Sanderson, Durham, N. H.; E. R. Sasscer, Washington, D. C.; Franklin Sherman, Jr., Raleigh, N. C.; J. B. Smith, New Brunswick, N. J.; R. I. Smith, Raleigh, N. C.; H. E. Summers, Ames, Iowa; T. B. Symons, College Park, Md.; E. P. Taylor, Mountain Grove, Mo.; James Troop, Lafayette, Ind.; R. A. Vickery, St.

Anthony Park, Minn.; F. L. Washburn, St. Anthony Park, Minn.; R. L. Webster, Urbana, Ill.; J. A. West, Urbana, Ill.; H. E. Weed, Chicago, Ill., and E. L. Worsham, Atlanta, Ga.

The following visitors were present:

C. C. Adams, Chicago, Ill.; G. G. Ainslie, St. Anthony Park, Minn.; J. C. Bradley, Ithaca, N. Y.; C. R. Crosby, Ithaca, N. Y.; J. R. Field, Boise, Idaho; J. C. Hambleton, Columbus, Ohio; J. D. Hood, Urbana, Ill.; P. L. Huested, Blauvelt, N. Y.; E. J. Kraus, Washington, D. C.; H. H. Lyman, Montreal, Canada; J. F. McClendon, Columbia, Mo.; J. G. Needham, Ithaca, N. Y.; L. M. Smith, Urbana, Ill.; L. R. Taft, Lansing, Mich.; Mrs. E. P. Taylor, Mountain Grove, Mo., and H. F. Wilson, Urbana, Ill.

The American Association of Nurserymen was represented by its President, Mr. J. W. Hill, Des Moines, Iowa, and by Col. C. L. Watrous, Des Moines, Iowa, Prof. John Craig, Ithaca, N. Y., and Mr. Orlando Harrison, Berlin, Md.

President Morgan called First Vice-President Summers to the chair while he presented the annual address.

The report of the Treasurer was read and referred to the auditing committee.

The Secretary reported that as no program committee was appointed at the last meeting, he had made up the final program and it had been printed and distributed. He also reported for the committee appointed at the last meeting to prepare and forward certificates of membership to the foreign members, and stated that this had been done. Several acknowledgments were read to the Association showing that the certificates had been received and were greatly appreciated.

The Secretary stated that he had made an attempt to codify the constitution, in accordance with a resolution passed at the last meeting, but found it very difficult to do so on account of several contradictory amendments. He therefore suggested that a special committee be appointed to revise the constitution and report, so that action could be taken at the next annual meeting.

By vote of the Association the report of the Secretary was accepted.

On motion it was voted that the chair appoint a committee of three to revise the constitution.

The Secretary read a list of proposals for membership which he had received and it was referred to the committee on membership. He also reported that the following members of the Association had resigned during the year: J. M. Aldrich, Moscow, Idaho; H. P. Gould, Washington, D. C., and Gerald McCarthy, Raleigh, N. C.

In view of the distinguished work which is being done in Crimea by Prof. Sigismond Mokshetsky, whose name had been proposed by Dr.

Howard, it was moved and carried that, as a special honor, he be elected a foreign member without the formality of having his name referred to the membership committee.

The President announced the appointment of the following committees:

Membership—Messrs. Summers, J. B. Smith and Forbes.
Resolutions—Messrs. W. D. Hunter, Washburn and Sanderson.
Nominations—Messrs. Osborn, Felt and Newell.
Auditing—Messrs. Sherman and Fernald.
Constitution—Messrs. Burgess, J. B. Smith and Symons.

As the standing committees elected at the last annual meeting were not ready to report, no further business was transacted until the afternoon session.

On motion of Mr. Symons, it was voted that the representatives of the American Association of Nurserymen, who had been invited to attend the meeting, be given the privileges of the floor.

Mr. Newell, the representative of the Association of Economic Entomologists on the joint committee on national control of introduced insect pests, presented the following report:

To the Association of Economic Entomologists:

At the last annual meeting, this Association elected one member to act on a joint committee on legislation, to be composed of one member each from the Association of Economic Entomologists, the American Association of Nurserymen and the Association of Official Horticultural Inspectors.

The members of this joint committee have been in correspondence with each other during the year and have today held a meeting at which a definite plan for securing uniformity in the certification of interstate shipments of nursery stock, has been decided upon. While this committee was elected with power to take all advisable action toward the end in view, nevertheless, the members feel that if the plan now decided upon by them be formally approved by the entire Association of Economic Entomologists, the legislation in view will be much more easily secured.

The committee asks your endorsement of the following plan of procedure:

A—Resolved, That the Secretary of Agriculture should be empowered to make regulations governing importations liable to harbor insect pests or plant diseases; to require such importations to be accompanied by a certificate of a duly accredited entomologist of the country in which said shipments originate, or, in the absence of such a certificate, to make inspections of such shipments by competent agents, at the point of destination, and that sufficient appropriation should be made for this purpose by Congress.

B—1. That Congress be asked to enact a law empowering the Secretary of Agriculture to issue certificates of nursery inspection, as nearly uniform as possible, to all nurseries in the United States engaging in interstate trade, upon proper inspection of such nurseries by duly authorized representatives of the United States Department of Agriculture, or by State officials approved by the Secretary of Agriculture for that purpose, and that sufficient appropriation be made therefor.

2. That all state or territorial officials in charge of nursery inspection be urged to accept these certificates at their face value, and that in states where laws are now in force which will not allow the acceptance of such certificates, the inspection departments be requested to endeavor to secure such state legislation as will make this possible.

C—That Congress should authorize the Secretary of Agriculture to proceed to exterminate or control imported insects or plant diseases, or any insect previously native to a restricted locality, but which may become migratory and threaten the whole country, whenever in his judgment such action is practicable, and that an appropriation be made for this purpose as a reserve fund for emergency use against any such pest which may arise.

The joint committee proposes to have two bills prepared for introduction into Congress; one of these embracing the subject matter of sections A and B, and the other embracing only the subject matter of section C, and that if the passage of both measures be found impracticable or impossible then all efforts be concentrated in the attempt to secure the passage of the bill involving the certification and inspection of imports and the control of nursery stock shipments entering into interstate trade, as above outlined.

Respectfully submitted,

WILMON NEWELL,
Member of Joint Committee.

It was moved and seconded that the report be received and that the recommendations of the committee be endorsed by the Association.

Mr. J. B. Smith favored laying the report on the table until it could be more thoroughly examined by the members, as he considered it unwise to take hasty action on the matter.

In reply Mr. Newell stated that the report is practically the same as that endorsed by the Association at the last annual meeting. The reason for desiring immediate action was that a number of the representatives of the nurserymen were obliged to leave the city that evening and, as they desired to have a bill drafted at once for presentation to Congress, they wished the further endorsement of the Association at this convention.

After a brief discussion the motion prevailed.

Mr. Hill, President of the American Association of Nurserymen, thanked the Association for the endorsement of the report and stated that the action taken would be of great assistance to the committee in securing the desired legislation.

The report of the Committee on Nomenclature was presented at the Saturday morning session as follows:

REPORT OF THE COMMITTEE ON NOMENCLATURE.

Your committee on nomenclature begs leave to report as follows:

First, that no additional list of names for final adoption is submitted at this meeting.

Second, that we recommend that the lists previously adopted be brought

together and published in full in the next proceedings, and also printed by the society in separate pamphlet form with a summary of actions concerning the use of common names adopted at previous meetings, for distribution to all members of the society, to agricultural journals, members of the Entomological Society of America and such other parties as the secretary and the committee on nomenclature may deem wise.

Third, that the use of these adopted names be again urged on all parties in publications of an economic character.

Your committee would also call attention to the action of the International Congress of Zoölogists in regard to the fixing of generic types, such action in substance being that a generic type once fixed or designated by whatever process is to stand as the type.

Respectfully submitted,

HERBERT OSBORN.
F. M. WEBSTER.

It was voted that the report be accepted and the recommendations adopted by the Association.

Mr. Sanderson presented a plan for publishing a journal on economic entomology. He stated that on the previous evening a number of the members who were interested in the matter had met and decided to form a company for the purpose, provided a satisfactory arrangement could be made for the journal to become the official organ of the Association. He presented a resolution in the form of an agreement for the consideration of the meeting. After some general discussion it was voted that the chair appoint a committee of three members to investigate the matter and report at the afternoon session.

The following committee was appointed: Messrs. J. B. Smith, Osborn and Bruner.

It was voted to make the reports of committees a special order of business, to be called up at 4.30 p. m., and that arrangements be made to hold a session at 8 p. m. to finish the reading of the papers remaining on the program.

At 4.30 p. m. the committee appointed to investigate the proposed journal of economic entomology presented its report, which endorsed the resolution presented at the morning session by Mr. Sanderson.

A brief discussion followed in which Mr. J. B. Smith called attention to the fact that this marked a complete change in the previous policy of the Association, and meant practically severing all connection with the United States Department of Agriculture. It might be a difficult matter to induce the Department to publish the annual report of the Association in the future, in case the journal should not be a financial success.

The report was amended in order to increase the advisory board

from five to six members, and to clearly define the method of their election, and it was then adopted by the Association in the following form:

That those hereto subscribing form a company for publishing a journal devoted to economic entomology, to be the official organ of the Association of Economic Entomologists; that this company will publish six issues a year of fifty to one hundred pages each, at a subscription price of one dollar ($1.00) to members and two dollars ($2.00) to non-members, in consideration of which the Association of Economic Entomologists agrees to publish its proceedings in said journal; that this company shall elect the editor and business manager, and that the advisory board shall consist of six members, to be nominated by the committee on nominations of the Association of Economic Entomologists and approved by the Association, which the company agrees to elect, two for one year, two for two years and two for three years, and that there shall hereafter be elected annually, in the same manner, two members to succeed those retiring; that the above-mentioned board with the editor and business manager shall determine the policy of the journal and shall control the matter published in it; that the subscription list for stock in the company shall be open to all members of the Association of Economic Entomologists, and to them only, at ten dollars ($10) per share, payable on demand.

The Committee on Membership presented the following report:

REPORT OF THE COMMITTEE ON MEMBERSHIP.

The Committee on Membership recommend the following:

For foreign members:

Prof. C. Gordon Hewett, Manchester, England, proposed by Dr. L. O. Howard.

Dr. Waldemar Pospielow, Station Entomologique, Rue de Boulevard No. 9, Kiew, Russia, proposed by Dr. L. O. Howard.

For transfer from associate to active membership:

Mr. R. C. L. Perkins, Honolulu, Hawaii.

For associate members:

Myron H. Swenk, University of Nebraska, Lincoln, Neb.

Harry S. Smith, University of Nebraska, Lincoln, Neb.

Paul R. Jones, Bureau of Entomology, Washington, D. C.

Henry Ness, Iowa State College, Ames, Iowa.

J. E. Buck, Agricultural Experiment Station, Blacksburg, Va.

R. A. Vickery, Agricultural Experiment Station, St. Anthony Park, Minn.

George A. Dean, Kansas Agricultural College, Manhattan, Kan.

Howard E. Weed, Chicago, Ill.

C. T. Paine, San José, Cal.

Charles Spooner, Agricultural Experiment Station, Durham, N. H.

B. H. Guilbeau, Baton Rouge, La.

George A. Runner, State Crop Pest Commission, Baton Rouge, La.

Arthur H. Rosenfeld, State Crop Pest Commission, Baton Rouge, La.

T. C. Barber, State Crop Pest Commission, Baton Rouge, La.

W. H. Goodwin, Agricultural Experiment Station, Wooster, Ohio.

Frederick B. Lowe, 6 Beacon Street, Boston, Mass.

H. O. Marsh, Bureau of Entomology, Washington, D. C.

J. A. West, Urbana, Ill.

Edith M. Patch, Agricultural Experiment Station, Orono, Me.

E. L. Worsham, Capitol Building, Atlanta, Ga.

Burton N. Gates, Bureau of Entomology, Washington, D. C.

Glen W. Herrick, Agricultural Experiment Station, Agricultural College, Miss.

John J. Davis, University of Illinois, Urbana, Ill.

To be dropped from membership (on account of having discontinued entomological work.)

J. M. Rankin, Leslie Martin, C. M. Walker, E. S. Hardy, W. O. Martin.

The committee further recommends:

That the committee on membership shall be appointed at the first session of each annual meeting, to serve until the appointment the next year of their successors, to whom the retiring committee shall transmit written recommendations concerning new members, promotions to active membership and names to be dropped from the roll.

The committee further recommends:

That the secretary be requested to have blanks printed for application for membership.

Respectfully submitted,

H. E. SUMMERS,
J. B. SMITH,
S. A. FORBES,
Committee.

By vote of the Association the report was accepted and the recommendations of the committee adopted.

The report of the Treasurer and of the Auditing Committee was as follows:

REPORT OF THE TREASURER.

Jan. 1-Dec. 27, 1907.	By amount received for dues		$111.00
Jan. 1, 1907.	To balance due on account of 1906	$16.40	
	paper and printing	5.00	
	express on manuscript	.55	
	stamps	1.00	
	printing	2.25	
	rent of typewriter	3.00	
April 20,	stamps	3.00	
" 25,	stamps	1.00	
May 1,	stamps	1.00	
" 24,	stamps	1.00	
Oct. 5,	stamps	4.00	
" 16,	printing certificates and blanks	12.25	
" 29,	express charges	.70	
Nov. 6,	mailing tubes	1.00	
" 15,	stamps	2.50	
" 16,	stamps	1.25	

Dec. 14, stamps	4.00		
" 21, telegram	.98		
Total amount expended,	$60.88		
To balance in the treasury, Dec. 27, 1907	50.12		
		$111.00	

Respectfully submitted,

A. F. BURGESS, *Treasurer.*

The Auditing Committee reported that the accounts of the treasurer had been examined and that they were found correct, and that a record of auditing had been made in the treasurer's book.

FRANKLIN SHERMAN, JR.,
H. T. FERNALD,
Committee.

These reports were accepted by vote of the Association.

The report of the Committee on Nominations was next presented:

REPORT OF THE COMMITTEE ON NOMINATIONS.

Your committee to nominate officers for the year 1908 begs leave to report as follows:

For President, Dr. S. A. Forbes, Urbana, Ill.

For First Vice-President, Dr. W. E. Britton, New Haven, Conn.

For Second Vice-President, Dr. E. D. Ball, Logan, Utah.

For Secretary-Treasurer, A. F. Burgess, Washington, D. C.

For Member of the Committee on Nomenclature, Prof. A. L. Quaintance, Washington, D. C.

For Members of the Council A. A. A. S., Prof. H. A. Morgan, Knoxville, Tenn., and Dr. James Fletcher, Ottawa, Canada.

For Member of the Joint Committee, Wilmon Newell, Baton Rouge, La.

Respectfully submitted,

HERBERT OSBORN,
E. P. FELT,
WILMON NEWELL,
Committee.

On motion the Secretary was instructed to cast the ballot of the Association for the list of officers reported by the committee and they were declared elected.

The same committee also presented the names of the following members to serve on the advisory board of the journal:

For three years, Messrs. Howard and Forbes.

For two years, Messrs. Fletcher and Morgan.

For one year, Messrs. Fernald and Osborn.

By vote of the Association these nominations were approved.

The report of the Committee on Resolutions was presented as follows:

REPORT OF THE COMMITTEE ON RESOLUTIONS.

The committee begs leave to report as follows:

Resolved, That the Association of Economic Entomologists expresses its appreciation of the courtesies extended by the University of Chicago, the local committee on arrangements, and the entomologists of Chicago; and

Resolved, That this Association hereby expresses its gratitude to Dr. L. O. Howard, Chief of the Bureau of Entomology, and the Honorable Secretary of Agriculture, for the editing and publication of its proceedings since its organization, and whereas in the infancy of this organization a means of publication was furnished it by Insect Life, published by the Division of Entomology, that this Association trusts that the staff of the Bureau of Entomology will make free use of the Journal of Economic Entomology now to be instituted as the official organ of this Association; and

Resolved, That the Association beholds with gratification the recent activity in the study of ticks concerned in the transmission of diseases or that may be found to be so concerned and urges the members to make further and more extensive investigations in this important field; and

Resolved, That the Association recommend that apiculture receive more attention from the official state entomologists and especially that attention be paid to the distribution and treatment of the brood diseases of bees; and

Resolved, That the Association expresses its appreciation of the valuable work being done by Prof. A. L. Herrera, of the Mexican Comission de Parasitologia Agricola, under conditions of peculiar difficulty, and that the Secretary be instructed to notify Professor Herrera of this action; and

Resolved, That the Association reiterates its expression in the resolution passed at the New Orleans meeting to the effect that wherever possible the Secretary arrange programs on the symposium plan.

W. D. HUNTER,
E. DWIGHT SANDERSON,
F. L. WASHBURN,
Committee.

At the suggestion of Mr. Fletcher, the committee submitted a special resolution on the gypsy moth work as follows:

Resolved, That the Association heartily approves the work now being done in the control of the gypsy moth and brown-tail moth by the state of Massachusetts and other states and by the Bureau of Entomology; and inasmuch as we have heard of criticism of this work from certain quarters, we hereby express our unqualified approbation of the present management and of the methods which it has adopted, and furthermore we would consider a change in policy as most dangerous to the vital interests concerned in the most important work in applied entomology that has ever been undertaken.

In discussing this resolution Mr. Fletcher called attention to the excellent results that are being secured from this work, and urged the necessity of a continuance of the same management and policy that has brought about these results.

It was moved and carried that the report be adopted. The special resolution was then unanimously approved by the Association.

The Standing Committee on Insecticides submitted the following report:

REPORT OF THE STANDING COMMITTEE ON INSECTICIDES.

Your committee on insecticides begs to present the following report:

1. After consideration of the list of insecticides submitted to the members of the Association for testing as reported to the committee of last year on this subject (which list is herewith appended) it seems to your committee that it is not advisable at the present time to undertake any coöperative tests of any of them.

2. Your committee recommends that all new proprietary insecticides offered to members of this Association be referred to this committee, who will then proceed, as suggested in the report of the committee on this matter of last year, part two.

3. The committee believes that it should ascertain whether it is possible to secure an interpretation or amendment of the national pure food and drug law so that it will include insecticides and fungicides, and if this is found impossible that the committee draw up and report to the next meeting of this Association a suggested law which will aid in securing uniformity of legislation in the various states, as regards the compulsory analysis and labeling of insecticides and fungicides.

Respectfully submitted,

E. D. SANDERSON,
E. P. FELT,
H. E. SUMMERS,
R. I. SMITH.

The following is, a list of insecticides submitted by the committee with the above report:

Arsenites: Swift's Arsenate of Lead, Green Death, Disparene, Green Arsenoid.

Scale insect remedies: Scalecide, Rex Lime Sulfur Wash, Target Brand Lime Sulfur Wash, Target Brand Scale Emulsion, Consol, Kil-o-Scale, Horicum.

Tobacco preparations: Rose Nicotine, Nikoteen, Rose Leaf Extract, Nicoticide, Tobacco Dust, Aphis Punk.

Larvacides: Phinotas Oil.

Tree Pastes: Tree Tanglefoot, Stone's Tree Paste, Borer Tanglefoot, Raupeuleim.

Soaps: Takanap soap.

Miscellaneous: Zenoleum, Orient Spray, Limoid, American Disinfectant, Carlson's Mixture, Kerosene Flour Emulsion, Pearson's Creolin.

Voted that the report be adopted and the committee continued.

The Secretary asked for instructions from the Association in regard to limiting the length of time to be allowed for the presentation of papers at future meetings. After some general discussion the following motion was made and carried:

"That the Secretary in calling for titles be authorized to request a fifteen-minute limit for papers, at the same time not necessarily limiting the length of important papers to that time; and that the time desired by each author be stated when submitting his title."

At the evening session the President called attention to the desire of the representatives of the American Association of Nurserymen to have a committee appointed to attend their annual convention at Milwaukee.

It was voted that a committee of three be appointed by the chair. The following members were selected,—Messrs. Forbes, Burgess and Symons.

Mr. Orlando Harrison, representing the above mentioned Association, thanked the Association of Economic Entomologists for the courtesies extended to the nurserymen during the meeting.

Immediately before adjournment Mr. W. D. Hunter presented the resolution which follows:

Resolved, That the thanks of the Association be extended to the President, Prof. H. A. Morgan, for the equanimity, for the genial good nature, and for the wisdom with which he presided over the meetings of the twentieth annual session.

This resolution was put before the meeting by Mr. Hunter and received unanimous approval.

President Morgan expressed his appreciation of the sentiments conveyed in the resolution, and with his usual unselfishness attempted to show that the Secretary was responsible for the success of the meeting.

There being no further business the meeting adjourned.

PART II

The annual address of the President was presented at the opening session of the meeting, Friday morning, as follows:

THE RELATION OF THE ECONOMIC ENTOMOLOGIST TO AGRICULTURE

By H. A. Morgan, *Knoxville, Tenn.*

The discussions of the systematic, developmental, and purely economic aspects of the subject of Entomology that have been presented before this body from time to time have indicated in a conspicuous way the broad yet definite field of the economic entomologist. In the interest of the future work of the Association these general boundaries should be maintained, as it is difficult to predict just when or where even the most remote biologic investigation, discovery or observation

will thread its way into some definite economic problem, or when a commonly recognized condition will induce a purely scientific search for the unknown cause.

In selecting for discussion at this time the relation of the economic entomologist to agriculture, it is not my purpose to restrict the interpretation of this relation to that which prevailed nearly a quarter of a century ago, when this Association was instituted, but to point out that larger interpretation which the wave of interest in agricultural education and investigation justifies, and which will be realized unless misdirection from one cause or another shall materially affect the present tide. Agriculture is in need of the entomologist, and the entomologist has a fruitful field in agriculture.

In the United States the land-grant colleges, made possible by the Morrill Act, in 1862, sent out the first organized tracer after a lost agriculture. A study of the history of many of these colleges in the light of present agricultural conditions indicates that the men who were placed in charge of these initial institutions were oftentimes without an agricultural compass and, what is worse, were without the sympathy and support of the people for whom the effort was being made. Hence, there was much time lost in adjusting a modern movement to old-time conditions. Not until the Hatch Act was put into operation, and investigational work was set in motion, did the complex nature of agriculture begin to be apparent. Through independent efforts of pioneer entomologists in some of the states, entomology had already found a place in the agricultural schedule, and upon the organization of the state experiment stations, entomologists were placed on the staffs; or the subject had won sufficient recognition to be associated with departments of biology or horticulture, already a part of the colleges with which the stations were affiliated.

The relation of economic entomology to agriculture was recognized by the nation prior to 1887, and, while not specified in the Hatch Act, its real relation to a state's agriculture was no doubt a part of the general conception of the author of the bill which gave each state an institution for agricultural investigation.

Some of the colleges receiving the benefits of the Morrill Act were giving limited courses in entomology at the time the experiment stations were organized. In others the number of insect forms had given taxonomic value to the study of entomolgy in zoölogical courses; while in others the economic aspect of insects was incidentally emphasized by the horticulturist or agriculturist in connection with some orchard, garden, or field pest.

Are we not justified in concluding, then, that when the spirit of investigation became effective in agriculture, economic entomology re-

ceived its logical setting? This may be true of many other sciences entering into composite agriculture; yet the peculiar relation of entomology to agriculture is conspicuous. Were this not true, the rapid strides that have been made in associating the two would have been impossible.

You will agree with me that with economic entomology unsatisfactorily associated, its future imperfectly projected, and with meager means for the preparation of persons for the work, the pioneers of this science merit commendation not usually accorded them. It is true that many of the men who took positions as entomologists of experiment stations in the beginning were better prepared for many other lines of work, but the wealth of opportunity for observation and investigation, and their application of these to agricultural progress, could hardly be mistaken. Now and then errors of observation were made and recorded, some of which unfortunately have been perpetuated by quotation to this time. It was to be expected, too, that certain easy methods and successful lines should drift economic entomological thought and activity into definite directions and veil for a time the real value of biological as well as ecological investigations and their application to preventive and remedial relief. The biting and sucking mouth parts were for a time the only recognized parts of an insect's anatomy, and hellebore, Paris green, and coal oil emulsion the standard substances in insect warfare.

The conceptions of the scope of entomological research as related to agricultural development have gradually but surely been expanded, until now a worker in this field finds himself involved in problems of very much wider range than the superficial anatomy of a common insect enemy of a local crop, or the compounding of a standard insecticide. Insects are related to diseases of live stock, as hosts of sporozoic organisms and nematodes, or as disseminators of diseases of bacterial origin; the importing and distributing of predatory and parasitic forms, and the adjusting of these to new conditions and even new hosts; the exact relation of insects to fruit and seed development; and the interrelation of insects, as in the case of ants and aphids, are all modern problems of economic entomology. While these questions are associated, either directly or indirectly, with agriculture, and are of great importance, I wish at this time to consider to what extent the student of economic entomology, in order to apply his knowledge to the best advantage, should be also a student of agriculture.

Within recent years deep-seated problems in connection with the occurrence of insects and allied forms have given prominence to lines of investigation of unusual merit in point of results. During the past season the army worm again appeared in destructive numbers in many

portions of Tennessee. Some observations were made of well separated outbreaks to determine if possible the reason for the unusual attack. In most cases the system of crop rotation and the farm practice were found conducive to the protection of the wintering forms under suitable climatic conditions. In the latitude of Tennessee a general rotation is corn, wheat, meadow. During average seasons corn land, after what is termed the "laying by," becomes foul with weeds, particularly a species of Ambrosia. This land, after the wheat is cut the second year produces a heavy growth of weeds from seeds of the previous year. The weeds are cut and left as a mulch for the meadow. This mulch affords protection for the army worm during winter and early spring of the third season, which results, if a late spring obtains, in the destruction of the meadow crop and the spread of the worms into contiguous fields. These observations place the burden of proof for the outbreak upon the corn crop and the practices prevailing in its cultivation. Preventive measures must be sought in a change in the rotation and possibly in the introduction of a new crop. Here agricultural information is demanded. The ravages of the sugar cane borer (*Diatreæ saccharalis*) have been traced to practices of handling the cane during fall planting, windrowing, and spring planting, and to the planting of corn on land previously devoted to second-year stubble. Here, again, a change in a rotation system and common practices of handling the crop are involved in preventive suggestions. In fact, the best methods of control of many of the insect enemies of a diversified agriculture are to be found in the adjusting of agricultural practice to biologic conditions. Evidence of this may be found in the recommendations for the corn root aphis, the Hessian fly, the cotton boll worm, the tobacco worm, the differential grasshopper, the North American cattle tick, the corn root worm, wireworm and cutworm, and many other pests of general distribution.

The invasion into the Southern States of the Mexican cotton boll weevil, and its effect upon a crop of international importance, enlisted unusual interest in methods of control. Growing out of the efforts made in connection with the boll weevil, more than any other insect, has the relation of detailed biologic study to the cultural methods of remedial relief been emphasized, if not permanently established. Never before have the importance of a study of agricultural conditions and the habits of most plants been so intimately associated in the development of preventive methods. Our standing with the farming fraternity and our opportunities to promote entomological investigation in its broadest and most acceptable field seem to suggest an intimate study of conditions that will protect in the most economical way the

interests of the crop producer. If a change in the system of cropping is necessary, recommendations in keeping with the best practice should be available. If postponement of the time of seeding will bring relief from insect attack, the influence on yields from other causes due to late seeding should be carefully studied, and estimated, and compared with the losses occurring from the damage under normal conditions. Some may think these matters belong to other departments of agricultural investigation, and that the recommendations which are the outcome of biological study should be turned over to other persons for their execution. Such action is not in keeping with the crop producer's estimate of agricultural organization, and he is an important factor in the successful development of any remedial plan. Delay consequent on the shifting of the execution of any method or methods is destructive of the best interests of agriculture and of the various sciences which make up its multifarious structure.

In concluding, I wish to express confidence in the opportunities offered to economic entomologists for the development of preventive and remedial measures against insect attack, by the timely correlation of a thoroughly matured knowledge of agricultural conditions with an exhaustive life-history and habit study.

The discussion of this address was postponed until the afternoon session.

A paper was presented by Mr. Smith:

CULTIVATION AND SUSCEPTIBILITY TO INSECT ATTACK

By JOHN B. SMITH, *New Brunswick, N. J.*

(Abstract.)

It is a common complaint in New Jersey by fruit growers that care best for their orchards, that some of their neighbors that never spray suffer less from the pernicious scale than they; and there is a basis of fact for the complaint. In almost every section of the state there are old orchards, chiefly apple, that bear annual crops of good or fair fruit, practically free from scale, though no spraying work is ever done in the orchards and the trees have been infested for years.

Investigation brought out a few facts that seem to be suggestive. *First,* as a rule, vigorous, sappy growth is much more generally infested and injured than slow, hardy growth. *Second,* trees growing in well cultivated orchards, highly fertilized, are much more likely to suffer from scale attack than others. *Third,* trees that grow slowly, or in sod, without much care, are much the more resistant to scale

attack. *Fourth,* trees that become infested while young and growing vigorously, suffer much more than trees that do not become infested until they have reached bearing age. *Fifth,* trees that have been infested for some years, have been more or less persistently treated so as to keep down the insects, and have then been abandoned, not infrequently clean themselves and become and remain practically free from scale afterward.

Some suggestions derived from these facts are, that possibly trees are being stimulated to rapid growth at the expense of hardiness, and that the nitrogenous fertilizers used to produce quick and large trees actually lessen resistant power to insect attack. It would seem in place to inquire whether there should not be a modification of our practice that would induce a hardier growth and one more resistant to scale attack. Instead of adopting a practice calculated to secure size, try to secure one that would give greater hardiness even at the expense of mere growth. That there is a variation in susceptibility among varieties is universally known; it should not be impossible by selection and proper treatment to secure both quality and resistance. It is unscientific to devote ourselves merely to securing and testing spray mixtures, however necessary these may be for immediate results, if there is a possibility of securing exemption by increasing resistance or by adoption of fertilizing methods more in accord with the real needs of the plants.

A general discussion of the paper followed. Mr. Taylor suggested that the fruit grower might lose more by failure to cultivate his orchard in order to dwarf the trees than he would gain by making them more resistant to scale attack.

Mr. Smith stated that the paper should not be construed as an argument to do away with the cultivation of orchards. It is possible that fertilizers might be used to advantage to produce a short, hardy growth rather than a large amount of new wood. He thought it might be desirable to use lime in the orchard and to reduce the amount of nitrogenous fertilizers.

Mr. Felt stated that he had observed in certain parts of New York the same conditions to which Mr. Smith had referred in his paper. He recalled several orchards where the San José scale is doing little, if any, injury, which is probably due to the condition of the trees.

Mr. Rumsey asked if anyone had noted any difference in susceptibility to attack in Ben Davis apple trees. No data on this point was presented.

Mr. Burgess remarked that in his experience the orchards which

make a very short growth of wood annually and are thereby enabled to resist scale attack are usually neglected by the owners and do not yield profitable crops of fruit. The best growers aim to secure a large amount of new, vigorous wood, as this insures better quality of fruit. This practice is particularly true in peach culture.

Mr. J. L. Phillips stated that in Virginia fruit growers are attempting to keep their trees in a vigorous condition and are able to secure profitable crops by spraying to hold the scale in check. The trees which are not being injured by the scale and where no spraying is being done, are neglected ones that are not a source of profit to their owners.

Mr. J. G. Sanders called attention to the fact that healthy, vigorous trees increased the fecundity and growth of infesting scale insects to a remarkable degree; the reverse being true in old, enfeebled trees. He stated that by transferring the cottony maple scale (*Pulvinaria innumerabilis*) to various vigorous plants he had reared forms that had been previously described as distinct species of that genus. By transferring this species from thickly infested maple trees to vigorous young lindens and sycamores he had secured specimens three times the size of the original females and a corresponding increase in egg production resulted.

President Morgan remarked that the paper under discussion was one that should interest the nurserymen and horticulturists and called on Prof. Craig for remarks. The latter expressed the opinion that the entomologists should go very slow in advocating any method of preventing scale injury along the line of doing less spraying or of practising less cultivation in the orchard. Fruit growers are always on the alert for some easy method of destroying this pest and he feared that statements of this sort from officials would be used by careless and indifferent growers as an argument for doing nothing.

A paper was read by Mr. Washburn:

FURTHER OBSERVATIONS ON THE USE OF HYDROCYANIC ACID GAS AGAINST THE FLOUR MOTH

By F. L. Washburn, *St. Anthony Park, Minn.*

(Withdrawn for publication elsewhere.)

The Secretary briefly reviewed a paper received from Mr. A. L. Herrera, Mexico City, Mexico, on "Notes on the Orange Worm" (*Trypeta ludens*), and exhibited a colored plate which accompanied the paper.

Mr. W. D. Hunter gave a description of the able work that Mr.

Herrera is doing in Mexico and referred to some of the difficult problems which he encounters.

Mr. Felt presented a paper as follows:

OBSERVATIONS ON THE BIOLOGY AND FOOD HABITS OF THE CECIDOMYIIDAE

By E. P. FELT, *Albany, N. Y.*

The species belonging to this family, though small and easily distinguished from most other Diptera, are exceedingly abundant and subsist in the larval stage under quite varied conditions. The majority of forms live upon plants and a goodly proportion produce galls. These peculiar structures occur upon the roots, root stalks or underground buds, along the stem, on the branches, on the leaves or even among the flowers or flower heads as the case may be. One genus for example, *Rhopalomyia,* attacks all parts of various Solidagos, except perhaps the root, the galls being quite varied in character and the adults from the same representing distinct species and, so far as known to us, coming only from galls possessing certain characters. On the other hand, *Asphondylia monacha* O. S., a most striking form, occurs not only in terminal rosette galls on the narrow-leaved Solidago, *Euthamia lanceolata* and *E. graminifolia,* but may breed in apparently unaffected florets of the same plant or may be found in what we have designated as adherent galls on *Solidago canadensis* and *S. serotina.* These latter structures are inhabited by two species belonging to as many genera and appear to be produced by the female laying eggs between the closely apposed young leaves in the rapidly growing bud. The larvæ cause a depression on each surface and the margins adhere, so that when the plant develops and the leaves turn down, the pair affected adhere at the point of injury though their bases are an inch or more apart. The form of the gall appears to be determined largely by the location and number of eggs the female deposits; for example, the midrib deformity on ash leaves, known as the gall of *Cecidomyia pellex,* may range in length from about ½ to 2½ inches. It appears to develop directly as a result of the larval irritation on the upper surface of the midrib; the size of the gall being proportionate to the number of larvæ, small ones having perhaps five or six, while the largest may have as many as 50 to 60. Certain species breed in more or less regularly rolled leaves, and in this case there seems to be a comparatively slight irritation and the form of the roll is governed mostly by the location of the larvæ and the structure of the leaf. Other species subsist in more or less irregular depressions, and here again the irritation is comparatively slight. There is one form, for example, which produces a slightly depressed rectangular area on the

underside of milk-weed leaves. The boundaries of the deformity are evidently limited by the stout reticulating veins characteristic of this plant. The circular ocellate gall on hard maple, known as *Cecidomyia ocellaris*, is presumably produced in the same way, and its form is governed by ordinary mechanical laws, as there are few rigid veins to modify its margin. The form of irregular subcortical galls on various shrubs and certain herbaceous plants appears to be determined very largely by the degree of infestation, and this is presumably limited by the egg-laying habits of the female. There are, in addition to the gall-making species, a number of forms which may breed in decaying wood, in other rotting vegetable matter, or subsist upon fungus or even prey upon other species such as Aphids and Acarids.

The duration of the life cycle varies greatly between the different groups, and in some cases, apparently among members of the same group. It is presumable that most of the Lasiopterines and the somewhat nearly related Rhabdophagas and their allies produce but one generation annually. The same is probably true of most of the Asphondylines and presumably of numerous representatives among the higher groups, including such well known species as the pear midge, *Contarinia pyrivora*, and the introduced European *Contarinia rumicis*, which breeds in the seeds of *Rumex crispus*. On the other hand, certain species like the Hessian fly, *Mayetiola destructor* Say and the violet gall midge, known as *Contarinia violicola*, complete the life cycle within a relatively few weeks, and the number of generations is governed almost entirely by climatic conditions and the presence of a supply of suitable food. A large number of our species winter within their galls in the larval stage. This is true of all Lasiopterines known to us which occur in subcortical galls, in stem galls and in at least certain of the blister galls. It is also the case with certain Hormomyias producing leaf galls on hickory. Others forsake the gall and winter in subterranean cells, possibly under vegetable debris and frequently in well-developed cells.

There are some exceedingly interesting correlations existing between these forms and their food habits. Among the Lasiopterines, for example, the genus *Clinorhyncha*, represented in this country by at least one introduced European species (*C. millefolii* Wachtl.) appears to breed entirely among the florets of certain compositae such as yarrow, tansy and the common daisy. Another genus, provisionally referred to *Baldratia* Kieff., breeds in very large measure in the peculiar, apparently fungous affected blister galls so abundant on solidago and aster, though at least one form has been reared from an apparently unaffected leaf of *Erigeron*. Larvæ belonging to *Lasioptera* occur largely in subcortical galls on the stems or branches

of certain shrubs and herbaceous plants, there usually being a number of larvæ in each gall. The botanical genera, *Solidago* and *Aster*, appear to be prime favorites with this group of insects. The willows, *Salix* species, have a peculiar fauna, and it is worthy of note that, so far as known to us, not a Lasiopterine has been reared from an American *Salix*, though a species of *Clinorhyncha* was taken on this plant. This is the more remarkable, as they occur abundantly in subcortical galls on a number of shrubs and trees such as *Sambucus, Viburnum, Lindera*, etc. The genus *Salix* appears to be a prime favorite with Cecidomyiidæ referable to *Rhabdophaga* or nearly allied genera. These insects produce varied subcortical galls on stems and branches, and are also responsible for several bud galls. The poplar, *Populus* species, differs markedly from *Salix* in its Cecidomyiid fauna. A European species of *Lasioptera* has been reared from this genus, while in America we have obtained but one species of *Rhabdophaga*, as contrasted with some ten or more bred from *Salix*. We have bred, presumably from poplar, a representative of the aberrant genus *Oligarces*. There are, in addition, a number of leaf galls occurring on poplar, upon which we are not prepared to report. Many representatives of the genus *Dasyneura* and its allies subsist in loose bud galls or folded leaves such, for example, as *Dasyneura leguminicola* Lintn., which breeds in clover heads, the European *D. trifolii* F. Lw. in the folded leaves of clover, and *D. pseudacaciæ* Fitch in the folded leaves of black locust. The larvæ of *Dasyneura flavotibialis* Felt subsist in fungous affected, rotting wood. *Oligotrophus asplenifolia* Felt was reared from the folded leaves of sweet fern, *Comptonia asplenifolia*, while several species of *Rhopalomyia* occur in large numbers in compound terminal heads of *Solidago*. Certain species of *Hormomyia* breed in some of the well known hickory leaf galls, while the larva of *H. crataegifolia* lives in a leaf fold on *Crataegus*. Some European species of this genus have been reared from galls in grass stems, and undoubtedly certain of our American forms have similar habits. Many members of the Diplosid group occur in folded leaves, loose tip galls or even in more or less abnormal florets.

Some of the incident perplexities of this work are illustrated by our having reared four species of Diplosids from florets of the spreading Dogbane, *Apocynum androsaemifolium*. A rather irregular, loose leaf fold gall on the base of hazel leaves may produce three or four species, while we have obtained two distinct forms from the rather well known tumid leaf gall on grape, ascribed to *Lasioptera vitis* O. S. There is, in addition, a petiole gall on grape which has produced three forms referable to as many genera, while the common horseweed, *Erigeron*, normally produces two entirely different species.

It is impossible to state at the outset just what material may or may not produce Cecidomyiidæ, since we have bred a species of *Lasioptera* from an apparently normal Diervilla stem only 1/8 of an inch in diameter.

Afternoon Session, Friday, December 27, 1907.

The session was called to order at 1 p. m. and the presidential address was discussed.

Mr. J. B. Smith stated that he considered the address very timely. He believed, however, that owing to the recent extension of the field of the economic entomologist that there is danger that he may unconsciously get out of his proper field of work. In insecticide investigations the entomologist should secure the coöperation of the chemist. He is satisfied that the diseases of the brown-tail and gypsy moths had destroyed more of the insects than the parasites, but in this field the work of the plant pathologist is needed. Certain cranberry insects have modified the entire plan of cranberry culture, while in the mosquito campaign in New Jersey, where about 15,000 acres of salt marsh have been drained by the construction of over 2,200,000 feet of ditches, the problem has become one of engineering to a large extent. He believed that when we get outside the range of entomology, experts in the allied sciences should be consulted.

Several other members expressed their appreciation of the address.

Mr. Newell presented the following paper:

NOTES ON THE HABITS OF THE ARGENTINE OR "NEW ORLEANS" ANT, IRIDOMYRMEX HUMILIS MAYR.

By Wilmon Newell, *Baton Rouge, La.*

It is not often that the economic entomologist is privileged to behold the coming of a new and dangerous pest, to see its numbers rapidly increasing for several years before it attracts more than casual attention from the "layman," and yet be practically powerless to avert the threatened catastrophe.

An insect problem practically unheard of by the majority of the members of this Association, is now presenting itself in the State of Louisiana, and will shortly present itself to most if not all of the southern portion of this country. It is, withal, a problem which in the writer's humble opinion will rank in magnitude alongside the problems presented by the San José scale, gypsy moth and boll weevil, but in marked contrast to these it is not likely to admit of remedial measures being as easily applied.

In his brief experience as an entomologist, the writer has not encountered or heard of any species which exercises its destructive abilities in so many different directions. As a household pest I venture the opinion that this ant has no equal in the United States. It is both a direct and indirect enemy of horticulture; direct by actual destruction of buds, blooms and fruit, and indirect by its fostering care of various scale insects and plant lice. In the latter role it becomes also an enemy of importance to shade and ornamental trees and plants. By its association with *Pseudococcus calceolariae* (Mask) it may wipe out, or at least make unprofitable, the production of cane sugar in the South. By its successful antagonism of beneficial forms it becomes doubly injurious. The varieties of *Solenopsis geminata,* now regarded as extremely important in the natural control of the boll weevil, are likely to be greatly reduced in numbers by *Iridomyrmex humilis* and thus the latter species may become the indirect cause of damage to the cotton crop. Even as a menace to human life, under certain circumstances, this little ant cannot be entirely ignored. To this I shall refer later.

History and Introduction.

The species was first described as "*Hypoclinea humilis*" by G. Mayr, in 1868, from workers collected in 1866 near Buenos Ayres in Argentina, the original description appearing in the *Annuario della Soc. Naturalisti Modena,* Vol. III, page 164. Following is Mayr's description of the species, kindly furnished by Dr. W. M. Wheeler of the American Museum of Natural History, from the original edition:

"Operia: Long, 2.6 mm. Sordide ferruginea, micans, mandibularum parte apicali flavescenti, abdomine nigrofusco, tarsis et nonnunquam tibiis testaceis; miscroscopice adpresse pubescens; absque pilis abstantibus; subtilissime coriaceo-rugulosa, mandibulis nitidis sublaevigatis punctis nonnullis; clypeus margine antico late haud profunde emarginatus; thorax inter mesonotom et metanotum paulo et distincte constrictus, pronoto fornicato, mesonoto longitrorsum recto, transversim convexo, metanoto inermi longitrorsum fornicato, pronoto paulo altiori; petioli squama compressa rotundata."

No mention of this species in the literature on economic entomology seems to have appeared prior to the publication of a paper by E. S. G. Titus, of the Bureau of Entomology, in the proceedings of the Seventeenth Annual Meeting of this Association,[a] reciting his observations made upon a trip to New Orleans in July, 1904, at the request of Prof. H. A. Morgan, who prior to that time, had recognized the dangerous nature of the pest. Mr. Titus's paper is replete with inter-

[a]Bulletin No. 52, Bureau of Entomology, U. S. Dept. Agr., p. 78-84.

esting information and in fact he secured a surprising amount of data in the limited time at his disposal. Since 1904 the species has frequently been referred to in the Louisiana press, usually as "the ant."

As with most imported species, the original time and place at which a foothold was obtained by the Argentine ant in Louisiana, must be largely conjectured. However, we are able to conjecture with rather strong circumstantial evidence to guide us. Not only does the testimony of inhabitants indicate New Orleans to be the original starting point of this species in the South, but its enormous numbers and the extent to which it has exterminated other species of Formicina confirm the opinion that it has been in New Orleans longer than elsewhere.

For the earliest record of its occurrence in New Orleans, I am indebted to Mr. Ed. Foster of the editorial staff of the New Orleans Daily Picayune. Mr. Foster has for years been a close student of insect life, and especially of Hymenoptera, so that his testimony may be accepted with the same confidence as that of a professional entomologist. Mr. Foster first noted *humilis* in New Orleans in 1891 and in a personal letter to the writer he thus gives the record:

"I have known the species since 1891. At that time it was a rarity in Audubon Park, but was very common in the section immediately above Canal Street. Below Canal Street it was not at all plentiful. The boundary of the nuisance then was virtually from Magazine Street to the river. The coffee ships from Brazil, I understand, have always landed about where the wharves are now situated (on the river front, adjoining the area above-mentioned), but from what we know of the spread of insect nuisances, the first batch of immigrants must have come in years before I came across their descendants."

Mr. Titus, quoting Mr. Baker, former Superintendent of Audubon Park, states that in 1896 "they extended over but a small area, reaching approximately from Southport docks to Carrollton Avenue, and from the river back to Poplar Street," and that "in 1899 they were first noticed in Audubon Park." This area, from Southport to Carrollton Avenue, is located about five or six miles northwest of the area between Magazine Street and the river, noted by Foster to be well infested as early as 1891. Mr. Baker therefore had not been familiar with the original area of heavy infestation, but merely noted the species after it had invaded the part of the town where he resided. Mr. Titus's information regarding the species being first noted in Audubon Park in 1899 was of course secured from citizens, who failed to note the ant until it had reached prodigious numbers in the same place that Foster had found it a "rarity" in 1891. The dissemination to Audubon Park was undoubtedly from the heavily infested area between Magazine Street and the wharves already referred to.

For years coffee ships from Brazilian ports have unloaded their cargoes at these wharves, and from what we now know of the habits of this ant, a ship could hardly set sail from any port where it occurs without carrying many workers and doubtless many queens as well.

On the authority of Prof. W. M. Wheeler[b], *I. humilis* is apparently a native of the Americas only in Brazil and Argentina. That the species was brought to New Orleans in the coffee ships from Brazil, seems so highly probable as to admit of little doubt. Incidentally it may be remarked that few, if any, merchant vessels now clear from the port of New Orleans during the summer months without having an abundant supply of *humilis* on board.

It may not be out of place at this point to call attention to the common name of this insect. The local name of "crazy ant"[c] has been applied to this species by some of the inhabitants of New Orleans, but it is far from being a desirable name. The most universal name in use is that of "New Orleans ant" and this seems to have been adopted by common consent on account of the species being so abundant in New Orleans. In view of the probable future importance of this insect the common name adopted now will likely remain a fixture in popular entomological literature.

It is manifestly unjust to attach the name of the Crescent City to this pernicious pest, for on neither the city nor its inhabitants can the responsibility be saddled for the introduction of this little ant.

As the species was first described from Argentina and as that country doubtless embraces a large part of the area in which the species is native, I should like to propose the name "Argentine ant" as being far more appropriate and specific than any yet suggested. I should like to see the species so recognized in the official list of insect names adopted and revised from time to time by this Association.

The dissemination of the Argentine ant from New Orleans to towns along the principal railroad lines within 200 miles of the city has not been particularly rapid, but has been very complete. To the eastward of New Orleans the infestation extends into southern Mississippi and to the westward as far as Lake Charles, La., a distance of two hundred miles, or nearly to the Louisiana-Texas state line. Down the Mississippi River the infestation is heavy the entire distance to the Gulf of Mexico, a distance of ninety miles. Northward the infestation reaches again into the State of Mississippi and in a more northwesterly

[b]Entomological News, Jan., 1906, p. 24.

[c]Since the above was written, Prof. W. M. Wheeler has advised the writer that the term "crazy ant" is applied in Florida and the West Indies to another species, *Prenolepis longicornis*.

direction at least as far as Alexandria, La., a distance of one hundred and ninety miles from New Orleans. Fully five thousand square miles are now included in the infested territory. Artificial dissemination is by far the most important means of distribution. Mr. Titus in his paper reviewed very completely this phase of the subject. Suffice to say that individuals by thousands, and even complete colonies, travel from infested points in shipments of groceries, feed stuffs, manufactured articles, timbers, etc. The spread of the species from the railroad towns into the surrounding country and into the broad fields of the large plantations is comparatively slow and in only a small part of the area designated as infested is the ant universally distributed through both town and country.

Economic Importance.

It is as a household pest that this ant has thus far attracted the most attention. Under houses, in dooryards, beneath outhouses, in compost heaps, in hollow trees and between the walls of dwellings the nests or colonies occur in abundance. From these nests foragers go forth by day and by night, being deterred only when the temperature falls below about 50° F. Whenever a foraging worker discovers anything which will serve as food hundreds and thousands of workers will gather within the half hour. In the case of my own residence, a new building, every square inch of surface in each room is regularly "patrolled" by the individual "scouts." No trunk, closet, book case, nor corner is left unexplored, and this despite the fact that since last spring I have waged constant warfare against them by destroying dozens of colonies with bisulphide of carbon.

Among the substances which serve the species as food may be mentioned sugars and syrups of all kinds, fresh meat, blood, lard, cream, fruit juices, honey, cakes and dead insects. Very few repellants are successful in protecting food stuffs. Even the time-honored method of placing table legs in bowls of water is but partially effective, for with the first accumulation of a dust film on the water the workers cross it without difficulty. In fact the surface film of perfectly fresh water is almost strong enough to support workers, and on more than one occasion I have seen a worker alternately swimming and walking across the surface of the water. Grocers, restaurant keepers and wholesale houses lose heavily by the inroads of this pest. A jug of molasses or a barrel of sugar, for example, containing several thousand ants is not entirely acceptable to the customer. The species does not sting, but can bite severely when so inclined, and sometimes becomes an annoyance to human beings. I have known of several cases where

people have had to place their beds, during the summer months, upon panes of glass covered with vaseline in order to pass the night in peace. There have been rumored cases of infants being killed by these ants, but so extreme a case has not come within my observation. That such might easily occur is not at all improbable. A neighbor of mine was awakened one night the past summer by the cries of an infant, about two months of age, lying in its cradle near at hand. Thousands of these ants were crawling over the child's body and into mouth and nostrils. It was necessary to repeatedly submerge the infant in a tub of water before all the persistent workers could be disposed of. Had the child not received immediate attention the consequences would doubtless have been serious.

The Argentine ant is particularly fond of the honey-dew secreted by Aphids and various scale insects, and in all localities the increase of Coccidae and Aphididae following the increase of these ants has been almost beyond belief. Many thousands of ornamental trees and plants in New Orleans have already been destroyed by scale-insects. Many complaints are also received that the workers eat into the petals and calyces of flowers of various kinds, and indeed it has now become almost impossible to produce cut flowers with profit in the city of New Orleans.

During the past autumn I have noticed the workers of this species assiduously attending the ordinary cotton plant-lice, apparently colonizing them upon the younger foliage. The cotton-louse is a species which is usually brought fully under control by natural enemies after the middle of June, but should this ant succeed in facilitating their increase during the summer and autumn these Aphids may come prominently to the front as enemies of the cotton crop.

As a direct enemy to fruit the ant is also important. At Audubon Park the past spring the entire prospective orange crop was destroyed by them, the workers eating into the opening fruit buds. Many complaints of this injury to oranges were reported to us from the lower Mississippi River and coast regions. The fig crop in the vicinity of New Orleans was this year almost entirely destroyed by them. The following, quoted from the New Orleans Times-Democrat of July 7, 1907, is not overdrawn: "The time of the ripening of the figs has come and the housekeepers have to watch the rich harvest of figs falling to earth day after day in their green immaturity from the beautiful trees that are so ant-infested it is almost impossible to pick the few that do ripen. The trees themselves are making a noble fight, but they will be conquered in the end, because the hordes that attack them are illimitable and possess a high intelligence simply marvelous when with our feeble human efforts we try to over-reach them."

It is in its relationship to the cane growing industry that *I. humilis* promises to be of most importance. Wherever this ant has become exceedingly abundant in the cane fields a mealy-bug locally known as the "poo-a-pouche" increases with great rapidity. This latter insect has been identified by Mr. J. G. Sanders of the Bureau of Entomology as *Pseudococcus calceolariae* (Mask). Not only does the poo-a-pouche heavily infest the growing cane, finding lodgment between the leaf and the cane itself and drawing heavily upon the sap, but in the spring of the year it is apparently colonized upon cane underground by *Iridomyrmex humilis,* and there it proceeds to destroy the germinating buds of the "plant cane." By way of parenthesis I should perhaps explain that one of the methods of propagating sugar cane is to plant the previous year's canes in rows during the winter and the bud at each joint develops the following spring, sending up a rapidly growing shoot. By the destruction of these developing buds below the surface of the ground in spring, the prospective cane crop is as completely destroyed as would be a crop of corn were some insect to devour all of the seed planted.

Mr. J. B. Garrett, of the Louisiana Experiment Stations, who has recently been making a study of this poo-a-pouche, finds that its distribution is by no means co-extensive with that of the ant, and that it occurs only in a small part of the territory now occupied by the latter. The poo-a-pouche occurs in destructive numbers on the plantations from New Orleans to the mouth of the Mississippi River, a distance of ninety miles. The fact remains, however, that this is the territory in which the ant is most numerous and most firmly established.

Mr. Garrett also expresses doubt as to the ant actually colonizing the poo-a-pouche upon the cane, and suggests at the same time that the unusual increase of the poo-a-pouche may be due to protection from its natural enemies, afforded by the ants. It happens that the varieties of cane most susceptible to this injury are among the best ones at present grown in the South. Unless some unforeseen factor injects itself into this problem, the entire sugar industry of the South will be threatened by this poo-a-pouche and the attending Argentine ant, which seems to be responsible for its rapid increase.

An interesting food habit of this species has become apparent to truck growers. The workers are very fond of lettuce seed and while we are not as yet certain that the lettuce seed are harvested from the mature plants, it is well established that the workers industriously dig up and carry to their nests freshly planted seed from the gardener's beds. In the infested territory some expedient has to be resorted to to protect the lettuce seed until they germinate, by which time they are safe from the attacks of this ant. The workers are fond

of corn meal, and if this be strewed thickly on top of the rows containing the lettuce seed, the ants will undertake to carry it away. By the time the meal is all removed, the lettuce seed has usually germinated. This practice is the most common one among the truck-growers. I have succeeded in protecting the lettuce seed by using tobacco dust scattered liberally on the ground over the seed, but it is not an entirely efficient repellent, for a small percentage of the workers burrow through it, seemingly without inconvenience or annoyance.

In what other fields this ant of cosmopolitan habits will become a disturbing factor remains to be seen.

Description.

In all the colonies which we have had under observation for several months, not more than three forms have been found, the females or queens, workers and males. Major and minor workers do not seem to occur nor do any individuals more than others act as soldiers or scouts. The original description of the worker by Mayr has been quoted above. As far as the writer can learn, the queen and male as well as the immature forms, have not heretofore been described.

At my request Prof. W. M. Wheeler has prepared a re-description of the worker, and descriptions of the queen and male, thus making a complete and comprehensive description of the species, which I give herewith:

Iridomyrmex humilis Mayr.

"*Hypoclinea humilis* Mayr. Annu. Soc. Natural Modena, 1868, 3: 144, No. 4, worker.

"*Hypoclinea* (*Iridomyrmex*) *humilis* Mayr, Verh. Zool. botan. Ges. Wien, 1870, 20: 954, 958, worker.

"*Iridomyrmex humilis* Emery, Zeitschr. f. wiss. zool. 46, 1888, p. 386. Taf. 28, Figs. 17–19 (gizzard).

Worker: Length 2.2–2.6 mm.

"Head oval, broader behind than in front, with its posterior margin slightly concave in the middle. Eyes flattened, in front of the middle of the head. Mandibles with two larger apical and several minute basal teeth. Clypeus short, convex in the middle, with broadly excised anterior margin. Frontal area and groove present but rather indistinct. Antennal scapes extending about one fourth their length beyond the posterior corners of the head. Joints 1–5 and the terminal joint of the funiculus distinctly longer than broad; remaining joints nearly as broad as long. Thorax slender, narrower than the head; broadest through the pronotum which is convex, rounded and nearly as long as broad. Mesonotum nearly as long as the pronotum, sloping, laterally compressed, in profile evenly continuing the contour of the pronotum. Mesoëpinotal constriction rather deep, extending obliquely downward and backward on each side. Epinotum short, nearly twice as high as long, convex on the sides, with a short convex base, and a longer, flatter and more sloping declivity. Petiole small, less than half as broad as the epino-

tum; its scale in profile, compressed, cuneate, inclined forward, with flattened anterior and posterior surfaces and rather acute apex; seen from behind its border is entire and evenly rounded or even slightly produced upward in the middle. Gaster small. Legs rather slender.

"Body minutely shagreened or coriaceous, subopaque and glossy; mandibles, clypeus and anterior border of the head more shining. Mandibles minutely and rather obscurely punctate.

"Hairs few, suberect, yellowish, confined to the mandibles, clypeus, tip and lower surface of the gaster. Pubescence short and uniform, grayish, so that the body has a slightly pruinose appearance.

"Brown; Thorax, scapes and legs somewhat paler; mandibles yellowish; apices of the individual funicular joints blackish.

Female (deälated): Length 4.5–5 mm.

"Head without the mandibles, but little longer than broad, with rather angular posterior corners, straight, subparallel sides and straight posterior border. Eyes large and rather convex. Mandibles and clypeus like that of the worker, scapes proportionally shorter and stouter. Thorax large, as broad as the head, elongate elliptical, nearly three times as long as broad. In profile the scutellum is very convex, projecting above the meso- and epinotum. Epinotum with very short base and long abrupt declivity. Petiolar node erect, more than half as broad as the epinotum. Gaster elliptical, somewhat shorter and a little broader than the thorax. Legs slender.

"Sculpture like that of the worker but more opaque; mandibles and clypeus also less shining.

"Scattered hairs more numerous than in the worker and also present in small numbers on the vertex, gula, mesonotum, prosternum and fore coxae. There is also a row of short hairs along the posterior margin of each gastric segment. Pubescence distinctly longer, more silky, and denser than in the worker.

"Dark brown; antennae, legs and posterior margins of the gastric segments reddish; mandibles, sutures of thorax and articulations of legs yellow.

Male: Length 2.8–3 mm.

"Head much flattened; including the flattened eyes, as broad as long. Vertex and ocelli prominent. Cheeks short. Mandibles small, overlapping, with a single, acuminate apical tooth. Anterior clypeal border straight. Antennae slender; scape only between three and four times as long as broad; first funicular joint globose, broader than any of the other joints; second joint much longer than the scape; joints 3–5 growing successively shorter; joints 6–12 considerably shorter and more slender. Thorax very robust, elliptical, broader than the head, which is over-arched by the protruding, rounded mesonotum. Scutellum even more prominent than in the female. Epinotum with subequal base and declivity, the former slightly convex, the latter feebly concave, forming an angle with each other. Petiole small, its node with rather blunt margin, slightly inclined forward. Gaster very small, elongate eliptical, with small rounded external genital valves. Legs slender. Wings with a four-sided discal cell and two well developed cubital cells. The costal margin is depressed or folded in just proximally to the stigma.

"Sculpture, pilosity and pubescence as in the worker; color more like that of the female, except that the antennae, legs, mandibles and internal genitalia are pale, sordid yellow. Wings smoky hyaline, with brown veins and stigma.

"*I. humilis* belongs to a small group of neotropical species embracing also *I. iniquus* Mayr, *dispertitus* Forel, *keiteli* Forel and *melleus* Wheeler. The workers of *keiteli* and *melleus* may be at once distinguished by their color, the former having a yellowish brown head and thorax and the remaining parts brownish yellow; the latter being pale yellow with a blackish gaster and funiculus. In these and in *I. iniquus* and *dispertitus* the mesoëpinotal constriction is much deeper than in *humilis* and the meso- and epinotum are of a different shape. The mesonotum in profile does not form a continuous, even line with the pronotum and the epinotum is very protuberant and almost conical. *I. humilis* represents a transition from the above group of species to that of *I. analis* Ern. André, which is very common in the Southern States. This species has a shorter, more robust thorax, more like that of *Tapinoma,* and much less constricted in the mesoëpinotal region.

"The above description was drawn from a number of workers, males and females taken from the same nest in Baton Rouge, La., by Mr. Wilmon Newell. The types described by Mayr were captured by Prof. P. de Strobel in the environs of Buenos Ayres."

An interesting point concerning the males, is that in certain colonies they occur in great abundance. This was first discovered by one of my assistants, Mr. G. A. Runner, who in December of 1907 found a colony in which the winged males were almost as abundant as the workers. Many other colonies which have been under constant observation for the past five months have not contained males at any time during that period. Prof. Wheeler has suggested that doubtless the appearance of a great many males in certain colonies is accounted for by the presence of egg-laying workers therein.

The Egg.—The egg deposited by the queen is elliptical, pearly white and without markings. As the time approaches for it to hatch it becomes duller in appearance but does not perceptibly change color.

The average size of the egg is .3 mm. long by .2 mm. wide.

The largest egg encountered while measuring a series was .34 mm. long by .24 mm. wide, and the smallest .27 mm. by .187 mm.

The rate of egg deposition has not been determined, but one queen under observation in a cage deposited at the rate of 30 eggs per day, now and then suspending oviposition for several days at a time.

The incubation period of the eggs in a glass cage in the laboratory extended from Oct. 1st to Nov. 15th, a period of 45 days, during which time the maximum temperature was 87° and the minimum 29°, with an average daily mean of 63°. Calculating the effective temperature from 43° F. and the actual mean for each day we find that 941 degrees of effective temperature were required for the develop-

ment of these eggs. This figure seems unreasonably high and I think it accounted for by the fact that I failed to provide the nest with sufficient moisture to make the conditions for incubation entirely favorable.

The Larva.—The larva when first hatched is hardly larger than the egg, and for some time after hatching remains curved, with the head and anal end practically together, so that the very young larva and eggs cannot be distinguished from each other without the aid of a good glass.

The larva is pure white, but with a dark color sometimes appearing in the abdominal region, as if it had been fed with some black or dark-colored food. When fully grown the larvae average 1.7 mm. long by .66 mm. wide.

Larvæ which were hatched from the eggs on Nov. 15, 1907, and which have been kept in a nest in my office, at ordinary living room temperature, now (Jan. 2, 1908) look to be fully grown and ready to pupate.

The Pupa.—The pupa in its earlier stage is pure white, without markings, except the compound eyes, which are jet-black and very prominent. As time for transformation approaches the pupa assumes a light brownish color, which gradually becomes a medium brown. So far as I can see there is no cocoon, or anything resembling it, surrounding the pupa, although the pupal skin, very thin and very fragile, is shed when the transformation to imago takes place. These pupal skins are carried out of the nest by the attendant workers. The color of the pupa in its final stage and that of the worker just transformed are practically identical, the latter requiring from two to five days after transformation to attain the deep brown color of the fully matured worker.

I have not secured any direct data upon the duration of the pupal stage, but from general observations my impression is that about three weeks' time, at an average temperature of 72° F. are required.

Habits.—Reference has already been made to the feeding habits of this ant, as well as to its relations with certain Coccidæ and Aphididæ. The colonies or nests are established in a great variety of places. We have found them in swampy ground where the earth was so wet that water would drip from it when squeezed in the hand. On the other hand I have found their nests between the walls of dwellings, where no moisture could reach them except such as was contained in the air. Nests have been found within hollow trees, beneath the rough bark of growing trees, in forks of trees, in rubbish and compost heaps, in decaying timbers, beneath boxes and boards, inside of brick foundations where accidental crevices occurred, in stored household goods,

and one colony was found domiciled between the tin wall and veneer covering of an abandoned kerosene can. In short, any locality that offers protection from the elements becomes a satisfactory home for this little creature. The species shows a marked tendency to construct nests in close proximity to any abundant food supply. If honey or molasses be placed in the same spot upon the ground for several days in succession, a small colony invariably burrows into the earth beside it. As to how new colonies are established, I am still very much in doubt. I have examined a considerable number of small nests which I knew to be but recently occupied, finding in them workers, eggs and larvæ but no queen. On the other hand I have found queens with foraging workers; one such was found with several hundred workers in a sack of sugar which was thoughtlessly left exposed for a few hours, and in rare instances a queen is seen crawling about unattended by any workers at all.

One of my assistants, Mr. G. D. Smith, has suggested that the communistic habit is carried by this species even beyond the colony itself and that colonies adjacent to each other form "communities," the inhabitants of which recognize each other as friends. There is indeed evidence to support this view. For example three colonies located in a line, about fifteen feet apart, were found to be in touch with each other, workers constantly traveling from one to the other.

The number of queens present in a colony may vary from one to many. I took as many as thirty-two queens from one colony and there were several more in sight when my supply of empty pill boxes became exhausted. It may be that the multiplicity of queens, and the age to which the workers attain, rather than the rate of oviposition, may account for the great abundance of individuals. The same theory might also explain why so many years have been required to bring the species into prominence after its introduction, as well as explaining its present strength. The increase of this pest strikes one as being steady and powerful, rather than sudden.

Though valiant fighters when other ants are encountered, the Argentine ant cannot be classed as a predaceous insect. I have yet to find them attacking any living insect or animal, the one exception being a cockroach which had been mashed, but which still possessed enough life to now and then move a leg or antenna. After insects are killed the ants feed greedily upon the body juices. They and my honey bees feed peacefully from the same dish of honey, and I have seen the ants clean off a bee which had been daubed with honey, without apparent annoyance to the latter.

Relation to Other Ants.—Prof. M. W. Wheeler, in Entomological News for January, 1906, gives an interesting account of how this

species obtained a foothold in Madeira and supplanted another introduced species, *Pheidole megacephala* Fabr.

In New Orleans where *I. humilis* is thoroughly established everywhere, it is rare indeed to find any other species. Titus in recounting his observations in 1904 said, "they have driven or killed out all other ants in the regions infested by them." The extermination of other species in the city of New Orleans has not been complete, but very nearly so. At Baton Rouge and other points which are now becoming quite heavily infested, the displacement of the native ants is easily observed. As examples I may cite two or three cases which have come under my observation. One day in August I noticed a small colony of *I. humilis* constructing a nest but a few inches distant from a colony of their near relatives, *Iridomyrmex analis*.[a] It was not long until the foraging workers from the *humilis* colony discovered their neighbors and whenever workers from the two colonies met a fierce battle ensued, usually ending in the *analis* worker being severely bitten and left to die. Five hours after these preliminary "skirmishes" were noticed I returned to the nest, to find *humilis* fully in possession and none of the former occupants of the nest anywhere in sight. The nest was dug up, but no trace of *analis* was found in it.

In September I witnessed an interesting attack by the *humilis* workers upon a fairly strong colony of *Solenopsis geminata*. The latter species is famed for its vindictiveness and for the effectiveness with which it uses its sting. In this case the victory was by no means an easy one for the Argentine ants, for the small (minor) workers of *geminata* were, one with another, as good fighters as the former. Both species made the petiole of the abdomen the objective point of attack, gripping it firmly between the jaws. About as many of the *humilis* workers were killed in these encounters as of the other species.

In attacking the larger (major) workers of *geminata* the *humilis* workers adopted somewhat different tactics. The *geminata* majors were several times larger than their antagonists and while far less active, quickly destroyed any *humilis* so unfortunate as to get between their mandibles. The Argentine ants therefore attacked them by rushing up and biting a leg or antenna and immediately retreating, sometimes as many as ten of the Argentines being thus engaged in the attack upon one of these major workers. Eventually the battle was won by *I. humilis*, purely by having innumerable reinforcements, and in about twenty hours had possession of the fortress they had stormed so long and faithfully.

The next morning in looking over the battleground I found many of the *geminata* major workers still alive but divested of all their legs.

[a]Determined by Dr. W. E. Hinds.

More interesting still was an attack made by Argentine workers upon the giant *Camponotus herculeanus* L., subspecies *pennsylvanicus* De G.[e] While watching a heavy stream of *I. humilis* workers passing up and down the bark of a large water oak tree one afternoon, three or four workers of the former species made their appearance, seeking food here and there on the same tree. Presently one of these giants crossed the line of *humilis* workers and was immediately attacked, the small ants fastening themselves to tibiæ, tarsi and antennæ and hanging on with bull-dog tenacity. With marvelous rapidity the large worker caught from one to three of her small adversaries at a time, crushed them between her jaws and threw them aside. She would reach from side to side and twist about to crush the little enemies clinging to her tarsi, but as fast as she could dispose of them others took their places. The extreme hatred which the little workers displayed towards this giant that had crossed their path was indicated by an Argentine worker which crossed the bark a couple of inches back of the *herculeanus* worker. Immediately the small worker changed its course and ran at full speed after the large one, catching up after traveling four or five inches, and at once attached itself to a hind tarsus. After watching this interesting battle for a considerable time the large worker was captured and placed in a cyanide bottle.

There are many other points to be mentioned in connection with this introduced pest, such as its probable future distribution, its natural enemies, measures of control, and the manner in which it is likely to affect various agricultural and commercial interests, were space to permit. The problem presented by this species is a large and complicated one and much tedious work of investigation will have to be done before the economic entomologist can claim a victory over this small but formidable foe.

This paper was listened to with much interest by the members present. Mr. H. E. Weed stated that workers of this species will carry food to their nests for a distance of three quarters of a mile. He said that people who did not live in the infested district utterly failed to appreciate the havoc that these insects were causing.

Three closely related papers were next presented, as follows:

LIFE HISTORY, HABITS AND METHODS OF STUDY OF OF THE IXODOIDEA.

By W. A. Hooker, *Bureau of Entomology, U. S. Department of Agriculture.*

The intention in presenting this paper upon the life history and

[e]Determined by Prof. W. M. Wheeler.

habits of the ticks is to give a brief resumé of our present knowledge of the group. The species found in this country, according to Banks' latest list, number no less than thirty-four, and aside from the North American Fever Tick *Margaropus* (*Boophilus*) *annulatus*, but comparatively little is recorded relating to their biology. In looking through the records for information as to the habits of exotic species, we find but little beside the valuable work of Prof. C. P. Lounsbury, the Entomologist of Cape Colony. Realizing their importance, particularly in relation to the dairy industry, he began an investigation of them in 1898. His studies present two results: first, the remarkable discoveries that several dreaded diseases of domestic animals in South Africa are transmitted through the agency of ticks; and second, the elucidation of the life history and habits of a number of species, including that of *Amblyomma hebraeum, Haemaphysalis leachi, Rhipicephalus appendiculatus, Argas persicus,* and more or less completely that of others. Wheler, in England, has given valuable information on the biology of the old world Linnaean species *Ixodes ricinus,* also found in this country, as has Prof. H. A. Morgan upon several species and Dr. H. T. Ricketts on *Dermacentor occidentalis.*

In connection with the study of the biology of the North American fever tick, the writer (under the direction of Mr. W. D. Hunter) has taken up the study of other species also, because of their importance as external parasites and because of their possible agency in disease transmission. In this work frequent reference has been made to the publications of the before-mentioned investigators. In addition the writer received valuable information and suggestions from Professor Lounsbury during his visit to this country the past summer. As a result nearly the complete life cycles of eight species represented in this country have been followed in addition to that of the North American Fever Tick *Margaropus* (*Boophilus*) *annulatus*, so that granting the life history and habits of the European Castor-bean Tick *Ixodes ricinus*, to be the same in this country as found by Wheler, in England, we are now acquainted with that of ten native species, and have data on two additional species.

The ticks are of primary importance in their transmission of disease. At least ten distinct diseases of man and the domestic animals are known to be thus transmitted, no less than sixteen species of ticks being implicated. Again they are of great importance as external parasites because they irritate and drain the system of the animal attacked and are followed in some hosts by the screw-worm fly (*Chrysomyia macellaria*), which deposits her eggs at these points of entrance, with resultant injury.

It is well known that in order to develop, it is necessary for the ticks to attach to and suck blood from some animal and that unless such host is found within a certain period, which varies mainly with the temperature and precipitation, that it will starve. Upon this knowledge as related to *Margaropus* (*Boophilus*) *annulatus* is based the method of freeing pastures by the so-called rotation system as first worked out by Prof. H. A. Morgan.

All ticks pass through four distinct life stages: the egg, the larva or seed-tick, the nymph or yearling-tick, and the adult or sexually mature stage. The female, following the engorgement of blood, becomes greatly distended and drops to the ground, crawls to some protective covering, and soon commences the deposition of large numbers of eggs. In the course of a few weeks these hatch into the six-legged larvæ or seed-ticks, which await the coming of, or in some species crawl to, the host. Having found a host they attach and soon engorge with blood, after which they either molt while attached or drop and pass a short period of quiescence during the metamorphosis, then appear in the eight-legged nymph stage.

A second engorgement takes place and the ticks either molt attached or drop as before, pass a period of quiescence, then molt and appear in the adult stage. Another, the third engorgement, is followed by dropping and oviposition, and the generation is completed. In the Spinose Ear Tick, *Ornithodoros megnini*, we find a variation from this. It drops as a nymph and, following the molt, without engorging as an adult, commences oviposition. In the genus *Argas* a second nymphal engorgement and molt takes place. In the family *Ixodidæ* death follows the completion of oviposition, but in the genus *Argas* of the family *Argasidae* repeated engorgement takes place, followed each time in the female by the deposition of eggs.

The appearance of the active stages of the ticks varies greatly from the unengorged to the gorged, excepting in the male, which does not engorge with blood, but seems to exist upon serum. Because of this variation in appearance, individuals of the same species have been described as different species. The nymphal stage can be separated from the adult by the absence of the genital pore. The sexes can only be distinguished after the final molt, except in a few species in which the high color markings can be seen through the nymphal skin a day or two prior to molting. As adults they are separated readily in the *Ixodidae* by the shield or scutum, which in the female covers but a small part of the dorsum, but in the male completely covers it. In the *Argasidae* the sex can only be distinguished by the shape of the genital pore, which in the male is crescent shaped, while in the female it is merely a transverse slit.

The position of the genital pore varies from midway between the front coxæ to midway between the posterior pair.

The ticks are naturally separated into three classes according to their habits of molting as suggested by Ransom: first, those which pass both molts upon the host, represented by members of the genus *Margaropus* and by *Dermacentor nitens;* second, those in which the first molt is passed upon but the second off the host, represented by *Ornithodoros megnini* of this country and *Rhipicephalus bursa* and *evertsi,* two South African species; third, those in which both molts are passed off the host, as is the case with most of the ticks found in this country.

A fourth class might be recognized to include those which drop to pass the first molt, but which remain upon the host for the second; as yet, however, no representative of this class has been found.

Of importance in connection with the transmission of disease is the fact that while the first class pass the entire parasitic period of a generation upon a single host, yet the second may attach to two and the third class to three separate hosts.

It will be seen that in the first class, where the ticks molt upon the host and instead of having to wait long periods to find a host, they merely continue sucking blood from the same animal. As a result these ticks reproduce very much the faster and become of greater importance as external parasites, where numbers and the removal of blood are considered. This is the case with our fever tick. In the class where both molts are passed off the host and a host found three separate times for each generation their chances of reaching maturity are lessened as compared with the first class by the proportion of three to one. They have overcome this great disadvantage it would seem by having become more resistant to heat and cold and by having gained the power to withstand much longer periods of fasting, as well as by having acquired adaptation of habits. This will be discussed under the heading of host relationship.

While the representatives of the first class, all belonging to the sub-family *Rhipicephalinae,* are more numerous, yet their greater importance as external parasites is to some extent surpassed by the third class, particularly by the members of the sub-family *Ixodinae,* owing to the fact that the much greater lengths of the hypostome permit of several times deeper penetration. As the result of this deep penetration by the *Ixodinæ,* an inflammation is produced ofttimes resulting in suppuration. Frequently in the attempt to remove ticks belonging to this latter class from the body of the host, the capitulum is separated from the body of the tick and remains embedded in the host. Lounsbury reports that in some sections of South Africa dairy

farming is becoming well nigh impossible in consequence of this deep penetration by *Amblyomma hebraeum*. Their attachment is followed by suppuration and sloughing of the teats; dairy herds in that country are often found in which one at least of the teats of each cow of nearly the entire herd is missing or injured so as to be useless.

With many species it is the habit shortly after hatching or molting to crawl upon nearby herbage, as grass, weeds and shrubs, or temporary structures, as fences and posts, and there await the approach of the host. When closely observed, the front pair of legs will be seen waving in the air, ready to attach to the host as it comes in contact, while with the other legs it holds to its support. In other species, as is the case with *Amblyomma hebraeum*, recorded by Lounsbury, the ticks are not satisfied with waiting, but start in search whenever a host comes near. In some species the waiting seems to be upon the ground.

Host Relationship.—Most species of ticks have certain hosts or group of hosts upon which they are largely dependent for existence. From this fact have arisen many of our common tick names, as the cattle tick, the dog tick, the fowl tick, the rabbit tick and many others. Many of these, however, more or less frequently attach to other hosts. The former may be termed the usual host or hosts and the latter the accidental or temporary host or hosts. There seems to be a rather close analogy between ticks and fleas as regards hosts. In his revision of the Siphonaptera, p. 268, Baker mentions rabbit fleas as remaining on a human being for some little time, biting frequently while there, still not frequenting that host nor its clothing or bed. He considers it very probable that many of the records of fleas refer merely to the temporary host, since the cases of temporary hosts are quite common. To illustrate how fleas would find these temporary hosts he mentions the possibility of the rabbit running into a badger hole, or the mouse into a mole burrow; that an owl's eating a mouse or a cat's devouring a rat would be favorable conditions for this temporary transference. Similar instances will account for many of our accidental hosts of ticks. Experiments conducted during the past summer by the writer have shown that when confined in a bag in close proximity to the scrotum of a bovine, nearly all of the Ixodids will attach. As a result of these accidental or temporary attachments for some species we have large host lists, including hosts upon which the ticks could only occasionally or never reach maturity. Lounsbury has found a peculiar habit in *Hyalomma aegyptium;* as a larva it will not feed on any mammalia, but attaches to fowls upon which the first molt is passed. Following the second molt, which takes place off the host,

with the exception of the dog, it attaches to almost all domesticated mammalia.

Mammals serve as the principal hosts of the ticks. Fowls are largely the hosts of the genera *Argas* and *Ceratixodes,* and of one or two species of the genus *Haemaphysalis.* Several species of the genera *Ixodes, Amblyomma* and *Hyalomma* are also parasitic upon fowls. The reptiles are not immune, several species attaching to them.

Adaptations as factors in Host Relationship.—It cannot be doubted that a great evolutionary process has taken place in the adaptation both of structure and of habits as related to reattachment and protection. It is not the intention of the writer at this time to enter deeply into a discussion of this matter but merely to mention the result of this great natural process as he sees it. This evolutionary process or survival of the fittest has resulted in the special adaptation, first of function and structure, and second of the habits of ticks.

All ticks must find hosts and attach at least once, some as many as four times. This necessity has resulted in *Special adaptation of function and structure for attachment.* An illustration of this adaptation of function is found in the way the Ixodids use the front pair of legs. As one approaches the free tick these legs can be seen waving in the air, while with the others it holds to its support. When a host comes in contact with them they cling to it most tenaciously with these legs. To determine the fact one has but to pass a finger rapidly over a cluster of the seed-ticks. The *adaptation of structure for protection* is represented by the engorged larvæ of *Argas miniatus* or *persicus.* Up to within a few hours of dropping these larvæ are globular in shape, but at this time they flatten and assume the typical Argas shape; this flattened form, natural to all of the other stages, permits the ticks to crawl rapidly and to secrete themselves in cracks and crevices protected from the wily fowl. In the *Ixodinæ* we find what may be considered specially adapted mouth parts, which being unusually long, penetrate deeply and prevent their being easily removed.

In the *adaptation of habits favorable to attachment and protection* we find most striking illustrations of the great process of natural selection. The adaptation of habits favorable to attachment may be placed in four classes: first, in molting; second, in attachment to any host; third, of habits to habits of host; and fourth, in acquired greater vitality. There is a great disadvantage in dropping to molt, for it necessitates long periods of waiting, and results in a high percentage of mortality from not finding the host. This disadvantage seems to have been overcome by some species which have acquired the habit of

molting on the host, for example, by the various species of *Margaropus* and by *Dermacentor nitens*. To this class belong several other species which have partially overcome this disadvantage in their passing the first molt upon the host. Two representatives of this class are the South African species, *Rhipicephalus bursa* and *evertsi*. A species of *Haemaphysalis*, which has recently been discovered by the writer to occur frequently upon the heads of birds in the southern part of the United States, also seems to have acquired this habit, at least partially, for it has been determined by the molted larval skins that the first molt is so passed. It has been overcome entirely by *Ornithodoros megnini*, the Spinose Ear Tick, in a somewhat different way, that is, by passing the first molt upon the host, then feeding sufficiently as a nymph, so that following the second molt, which takes place off the host, engorgement as an adult is unnecessary for oviposition and probably never occurs.

Even in species most diverse in their tastes there are some hosts especially favored; this in some cases may be accounted for by the great numbers of that host.

In the class which has adapted its habits to the habits of the host, the ticks are confined largely to a host or group of hosts with similar habits. In the studies of the ticks made by the writer, these adapted habits have been found most interesting. The species *Haemaphysalis leporis palustris*, commonly known as the Rabbit Tick, has adapted itself to the habits of the Leporidæ, the hares and rabbits, and only accidentally attaches to other hosts. It is the habit of the hares and rabbits to remain more or less inactive during the day in their "forms" or resting places, protected by a clump of grass or bushes from enemies such as birds of prey, their activity being largely at night. The writer has found that this tick following engorgement drops largely during the day, in other words when the hares and rabbits are in their forms or resting places, to which places they or others return to pass the day. Thus, when the ticks have hatched or molted and are ready to attach, they have little trouble in finding the host. This same habit has been acquired by the Fowl Tick, *Argas miniatus*, which in the engorged larval stage, the writer finds drops only at night (except accidentally) when its host, the fowl, is upon the roost. Thus when ready to re-attach it is near and readily finds the host, whereas had it dropped during the day when the fowl was on the "run" the chances of its finding a host would be greatly lessened. A habit apparently acquired by *Ornithodoros megnini* is that of crawling to a height of several feet from the ground as a nymph before molting and depositing its eggs; thus when the seed-ticks appear ready to attach they will be rubbed off by the horse, cow or other host and readily find

ADAPTATIONS AS FACTORS IN HOST RELATIONSHIP.

- Adaptation in the ticks.
  - Adaptation of function and structure.
    - for attachment
      - represented by the adaptation of the front pair of legs of the Ixodidae, to attachment.
    - for protection
      - represented by shape of engorged larval nymphs and adults of *Argas miniatus* and by the increased length of mouth parts of the Ixodinae.
  - Adaptation of habits.
    - for attachment
      - 1-molting on host.
        - *Margaropus* sps., *Dermacentor nitens*, etc.
      - 2-attachment to any host.
        - Many species.
      - 3-adaptation of habit to habit of host.
        - *Argas miniatus*, *Haemaphysalis leporis palustris*, *Ornithodoros megnini*.
      - 4-acquired greater vitality.
        - Many species.
    - for protection
      - 1-accelerated engorgement.
        - *Argas miniatus* and *persicus* *Margaropus*, *annulatus*, etc.
      - 2-position of attachment to body.
        - *Ornithodoros megnini*, *Dermacentor nitens*, *Haemaphysalis* sp. on birds.
      - 3-nocturnal habits.
        - *Argas* sps.

access to the ear. These species furnish what evidence we now have of the adaptation of habits to the habits of the host, but I have no doubt that similar habits will be discovered in other species when they have been given sufficient study.

It seems probable that in the species which drop to pass their molts greater resistance to high and low temperatures and the power to withstand long periods of fasting have been acquired. Again the species which have acquired the habit of molting on the host has probably lost in this power of resistance.

As related to protection, the *adaptation of habits* may be considered under accelerated engorgement, attachment to favorable part of body, and nocturnal habits. Of *accelerated engorgement* we have several instances among the ticks. This is best illustrated by *Argas persicus* and *miniatus* in their engorging within a few hours at the most. Lounsbury argues that they are descendants from forms which remained for days at a time on the host. That this is the case is shown by the larva, which still remains upon the host for days to engorge. In the Cattle Tick, *Margaropus annulatus,* after it has become about one third engorged, which requires a number of days, complete engorgement takes place and the ticks drop within a comparatively few hours. In this way the chances of destruction due to the removal by enemies such as birds and the attack by parasites have been reduced to the minimum.

Again we find species which have adapted their habits for protection in attaching to favorable parts of the body as have *Ornithodoros megnini* and *Dermacentor nitens* in attaching to the inside of the ears. The species of *Haemaphysalis* found upon quail, field larks (and other ground-feeding birds) in Texas, Lousiana and Florida, appear to attach only to the head, a place from which they are not easily removed by the fowl. Perhaps the most highly developed habit acquired by ticks for protection is that found in the nocturnal habits of the genus *Argas.* Through this habit of resting during the day time, they escape detection by the fowls, which, upon discovery, devour them with great avidity. At night the fowls come to their roost near by and the ticks have little trouble in finding the host and engorging at a time when the fowl is inactive, and thus largely escape detection and destruction.

Mating.—In the *Argasidæ* mating takes place after the final engorgement has occurred and the tick has left the host, but few observations having been recorded. In *Ornithodoros megnini* the nymph leaves the host, molts, and without further feeding is fertilized and commences oviposition.

In the *Ixodidæ* the mating appears normally to take place upon the

host, but some species have been observed in copulation off the host. In most of the species which pass their molts off the host (the genus *Ixodes* possibly excepted) it seems to be necessary that the male at least attach and take food before the sexual instinct is developed. In *Margaropus annulatus*, which molts upon the host, the male detaches as soon as the nymphal skin is shed and goes in search of the female, which it embraces when found and with which it remains in copulation until the replete female drops. The Brown Dog Tick, a species of *Rhipicephalus*, has similar habits, females often being found each with several males attempting to embrace them. Apparently *Dermacentor nitens* also has the same habit of remaining in copulation on the host. While the two sexes are usually nearly equal in numbers, yet by the dropping of the female and remaining of the male on the host, the latter are usually found present on the host in greater numbers. Lounsbury has made extensive observations upon the mating of *Amblyomma hebraeum*, the habits of which species are very remarkable. He has found that the female goes in search of the male, the latter accepting the female only after having attached and fed for several days. Considerable difficulty has been experieneed by the writer in getting the sexes of the three species of *Amblyomma* and *Dermacentor variabilis* to copulate, and there remains much to be learned in relation to this habit. Mr. J. D. Mitchell has observed *Amblyomma americanum* apparently in copulation on shrubbery. Wheler mentions observing *Ixodes ricinus* as apparently in copulation off the host; this act he describes as taking place through the introduction of the mouth parts of the male into the genital pore of the female. The writer has observed this same habit in *Ixodes scapularis*, both upon and off the host. An unengorged, unattached female taken in the field from a hunting dog and placed in a pill box with unattached males taken from the same dog was shortly after found in copulation with one of the males. From this it would appear that it is unnecessary, for the female of this species at least, to take food prior to fertilization. The habit of fertilization through the introduction of the male mouth parts into the genital opening of the female thus appears to be typical of the genus *Ixodes*.

Geographical Distribution.—While ticks are found which have adapted themselves to colder climates, it is in the tropics that they are found in the greatest numbers. That the distribution of species is controlled by cold is well illustrated by the original quarantine line against the cattle tick in this country. Humidity and precipitation also appear to be factors in control of the distribution, as in the case of the Gulf Coast Tick, *Amblyomma maculatum*, a species found in the immediate vicinity of the Gulf Coast from Cameron Parish, Louisiana, to the Rio Grande River in Texas.

Life History and Habits of the Genera and Species.—The life history and habits of the *Argasidae* are quite different from those of the *Ixodidae*. The Argasids are represented by the two genera *Argas* and *Ornithodoros,* the species being comparatively few in number. Some of these, known as man-attacking ticks, have had the reputation from the effect of their bites of producing critical conditions. Livingstone, in the account of his travels in Africa, speaks of the ofttimes serious symptoms and occasional fatal result following their attack. Lounsbury in the investigation of this effect permitted specimens of *Argas persicus* and *Ornithodoros savignyi* (the Tampan Tick), two species implicated, to feed upon his arm, and concludes that while they may be productive of considerable irritation and their penetration serve as entering point for some of the abscess-forming bacteria, as *Streptococcus pyogenes,* etc., yet otherwise their direct effect is harmless. They may, however, transmit disease in both man and the lower animals. Dutton and Todd have shown *Ornithodoros savignyi var caecus* (*moubata*) Neum. to be the agent in the transmission of a spirillum which produces a disease of man known as human tick fever. This may account for the reputation that they have borne in Africa.

In the genus *Argas* the nocturnal habit is developed. They remain hid away by day, coming out from their places of hiding by night to find the fowl host and engorge with blood. The genus is represented in this country by two species, *sanchezi* and *miniatus.* Of the former species, known as the Adobe Tick from its habit of frequenting adobe houses, little or nothing is known as relating to its life history. *Argas miniatus,* commonly known as the Fowl Tick, is a species very similar in structure, life history and habits to that of the old world *Argas persicus,* and is probably at most but a variety of that species. The life history and habits have been carefully worked out by Lounsbury in South Africa and the similarity of our species in life history and habits has been determined by the writer. *Argas miniatus* is of importance because of its attack upon poultry; in sections of Southwestern Texas it has made profitable poultry raising impossible. As a larva, this tick attaches to a fowl, preferably beneath the wings, remains attached for five or six days, becomes engorged, and, a few hours before dropping, flattens out and assumes the typical Argas shape. As mentioned in the discussion of host relationship, it has been found that the larvæ drop only at night, at a time when the fowl host is upon the roost and where it will be near the host when ready to engorge again. In summer a period of four or more days passes before molting of the engorged larvæ takes place and the eight-legged nymphs appear. The second engorgement, always at night, lasts but a few hours at the

most and is followed in summer by five days before the second molt and the appearance of the second stage nymph. A third engorgement occurs at night (in the latter part of August) and twenty-six days pass before any of the ticks molt and appear as adults. A fourth engorgement then takes place, the sexes copulate and eggs are soon deposited. Unlike the ticks of all other genera, so far as known, these ticks re-engorge a number of times as adults, and the re-engorgement is followed each time by oviposition. The eggs hatch in summer in about fifteen days. The longevity of these ticks and their resistance to insecticides is remarkable.

The genus *Ornithodoros* is represented in this country by the two more common species *turicata* and *megnini* and two but little known species, *coriaceus* and *talaje*. But little is known of the life history of *turicata*, which Lounsbury suggests as being identical with the African species *savignyi*. *Ornothodoros megnini*, known as the Spinose Ear Tick, from spines of the nymph and its habit of infesting the ear, is a species found frequently in some parts of the South in the ears of cattle, horses, sheep, and a few other animals. The life cycle, which has been followed by the writer, is found to be this: Seed ticks, having gained entrance to the ear, attach deep down in the folds, engorge, and in about five days molt; as nymphs with their spinose body they appear entirely unlike the larvae. As nypmhs they continue feeding sometimes for months. In experiments made by the writer the first nymph to leave had remained in the ear thirty-five days from the time it entered as a seed tick; others still remain in the ears at the time of writing (December 7th), a period of ninety-eight days having passed since they entered as seed ticks. After leaving the ears as nymphs, these ticks usually crawl up several feet from the ground and secrete themselves in cracks and crevices, where, in about seven days in September, after leaving the ear, they shed a membranous skin and appear as adults without the spines. Fertilization then takes place and oviposition commences, the female dying with its completion. Unless fertilization takes place, eggs are not deposited and the ticks live for a long period. The incubation period in summer is as short as eleven days. Owing to their habit of remaining for long periods in the ears, they can be carried great distances. This fact may account for their being reported from some of the northern states.

The second family, the *Ixodidæ* or typical ticks, is represented in this country by nine genera, including thirty recognized and described, and several undescribed, species. The life cycle of species of the genera *Margaropus, Rhipicephalus, Dermacentor, Haemaphysalis, Ixodes* and *Amblyomma* has been followed. The greater number of these drop to pass both molts off the host. Of the species found in

this country *Margaropus annulatus* and *Dermacentor nitens* pass both molts on the host and a species of *Haemaphysalis,* found in Texas, Lousiana and Florida upon birds, has been determined by the attached molted skins to pass at least the first molt upon the host. In the species which molt upon the host, molting closely follows engorgement, but in the species which drop to molt there follows a quiescent period of two weeks or more.

All species of the genus *Margaropus*, so far as known, pass both molts upon the host. The single species of the genus found in this country, *annulatus,* attaches to cattle, horses, mules, donkeys, deer, and occasionally to sheep, goats and dogs. The larvae following attachment engorge to repletion and molt in six or seven days; then follows a similar period of engorgement as a nymph and another molt. Appearing as an adult, the male searches out the female, and copulation continues until the engorged female drops, which may be as soon as five days after molting. In summer deposition commences in three days after dropping and an incubation period of twenty-one to twenty-five days follows.

Most species of the genus *Rhipicephalus* pass their molts off the host, as is the case with the species found in this country. Lounsbury, however, has found that a South African species, *Rhipicephalus evertsi,* passes the first molt upon the host. The Brown Dog Tick, an undescribed species near *sanguineus* and the sole representative found in this country, engorges as a larva and drops in from three to seven days following attachment. A quiescent period of twenty days as the minimum was found to be passed at Dallas in October before molting commenced. As nymphs a period of engorgement of four days or more is passed before dropping occurs; this is followed by a quiescent period of fourteen days in October, when molting commences. As in *Margaropus* the male searches out the female and remains in copula until she drops, engorgement of the adult female taking about a week. Deposition of eggs commences in three or four days after dropping. At Dallas eggs deposited May 17th commenced hatching in twenty-five days. The usual host of this species is the dog, so far as is known, no records of other hosts having been made.

In the genus *Dermacentor* we find species of the two classes, i. e., those which drop for both molts and those which pass both molts on the host, the first represented by *occidentalis* and *variabilis* and the latter by *nitens.* Doctor Ricketts has determined this habit in *occidentalis* from material collected in Montana and has furnished some additional data on their habits.* He reports horses and cattle as hosts in Montana. It has been determined by the writer at the

*Journ. Amer. Med. Ass'n, p. 1069 (Oct., 1907).

Dallas laboratory that *Dermacentor variabilis* in the larva stage, attach, engorge and commence dropping in four days; a quiescent period of seven days or more passes before the molt takes place. The nymphs then engorge in about five days and pass a quiescent period of seventeen days (in September at Dallas) before molting. Considerable difficulty has been experienced in getting adults to attach and engorge, owing probably to a failure to understand what Lounsbury calls the courtship. A male that had previously fed and a female unfed were confined upon the scrotum of a bovine on November 1st; these attached and reattached a number of times, but up to November 14th had not been found in coito, though examined twice daily. On November 14th the female, having nearly fed to repletion, was found in copulation with the male, remaining in this relation for about twenty-four hours, but separating a number of hours before dropping. Dropping took place on the 15th, a period of over two weeks from attachment. Professor Morgan, however, reports that he has found the female to engorge in from five to eight days. The incubation period of eggs deposited the latter part of June was twenty-seven days. This species usually chooses the dog as its host, although it has been found upon a number of other mammals. *Dermacentor nitens,* the Tropical Horse Tick, a species found in Texas from Brownsville to Corpus Christi, has been determined as passing both molts upon the host. It is found largely in the ears, although from lack of room it sometimes attaches in the mane of the horse. The horse is the common host, although a few specimens have been taken from the ear of the goat.

Two species of the genus *Haemaphysalis, leporis palustris,* the Rabbit Tick of this country, and *leachi*, the Dog Tick of South Africa, pass both molts off the host. There is a species of *Haemaphysalis* found throughout the South, upon quail and other birds that feed upon the ground, which, although its life cycle has not as yet been followed, has been determined by the writer as passing (at least occasionally) the first molt upon the host. This species may prove to be *leporis palustris,* which is found so commonly upon the rabbits (with a somewhat changed habit of molting) or it may be *chordeilis*. This will soon be determined, but as yet the adults have not been obtained. The life cycle of *Haemaphysalis leporis palustris* has been partially followed by the writer at Dallas and the part remaining will soon be completed. The larvae engorge and commence dropping on the fifth day from attachment; in October they were found to remain quiescent eighteen days before molting. Nymphs attached and engorged in six days, those dropping November 4th not having molted at the time of writing (December 7th). It has been determined by large numbers of larvae

and lesser numbers of nymphs to be the habit of the engorged stages to drop during the day time. As mentioned under host relationship, this appears to be a remarkable adaptation to the habits of the host on the part of the tick. It is the habit of the hares and rabbits to remain during the day time in their resting places, which are commonly known as "forms." These forms are made by scratching in the grass beneath weeds or brush and furnish protection from the sun and enemies, such as the birds of prey. At night they become active, being protected from enemies by the darkness. Thus it is seen that the ticks by dropping during the day time in or near these forms readily find the host after hatching or molting.

In the genus *Ixodes* the life cycle of but a single species has been followed, that of *Ixodes ricinus* by Wheler in England. While there are fourteen species reported from this country, but few have been collected by agents of the Bureau, and these only occasionally. In Florida the writer has found *Ixodes scapularis* to be quite common on dogs, but because he was not acquainted with the fact that the members of this genus require more moisture than most other ticks, these died without development. Wheler finds *Ixodes ricinus* to drop for both molts, as is probably the case with the other species of the genus. He reports the larvae to engorge and drop in two days; that in winter (February to April) eleven weeks pass before they molt. Of the periods of engorgement of the nymph and adult we are not informed. Engorged nymphs removed May 29 molted three weeks later and an engorged female removed April 15 commenced oviposition on the 27th day following. While this species occurs in this country, it has been taken but once in Texas by agents of the Bureau, although extensive collections of ticks have been made. Immature stages of an undetermined species have been taken from the heads of birds by the writer.

The species of the genus *Amblyomma,* the life cycles of three of which *(americanum, cajennense* and *maculatum)* have been followed by the writer and that of the South African species *hebraeum* by Lounsbury, all appear to drop to molt. The genus is represented in this country by four species, the three mentioned and *tuberculatum.* Aside from *tuberculatum,* which has been found only on the land turtle in Florida, the species are not closely restricted in their host relations. The Lone Star Tick, *Amblyomma americanum,* as larvae engorge in three days, drop and commence molting eight days later; as nymphs similar periods are necessary for engorgement and molting; as adults eleven days was the quickest period in which engorgement and dropping took place. After dropping, at least eight days were found to pass before oviposition commenced. The minimum incubation period recorded is for eggs deposited June 25, when 27 days

were necessary. The Gulf Coast Tick, *Amblyomma maculatum,* as a larva engorges and drops as soon as the third day from attachment, and in the latter part of September, eleven days were necessary for molting. As nymphs, five days were necessary for engorgement, ticks that dropped November 3d not having molted at the time of writing (December 7). This species is the largest found in the United States. When fully engorged it measures two thirds of an inch in length. It also deposits the largest number of eggs, those from one specimen recorded numbering 11,265. The Cayenna Tick, *Amblyomma cajennense,* as a larva engorges and drops on the third day, following which eleven days are necessary before molting takes place. As a nymph, three days as in the larva were necessary for engorgement, and fifteen passed before they molted. The adult was found to engorge and drop in seven days. The incubation period of this species seems to be much longer than that of the other two native species studied, eggs deposited the latter part of May requiring five weeks before hatching commenced.

The species of the genus *Ceratixodes* are apparently all parasites of marine birds, little or nothing being known as to their life history and habits. *Ceratixodes signatus* Birula was described from specimens taken from Alaska. It has since been taken from cormorants in California. *Ceratixodes putus* Camb. has also been recorded from Alaska. Banks now considers *Ceratixodes borealis* K and N, a synonym of *putus.*

The Methods Used in Breeding Ticks.—So far as possible the usual host should be used in determining the parasitic periods in order to eliminate any possible variation from the normal condition.

In the ticks which pass both molts upon the host, as does *Margaropus (Boophilus) annulatus,* it is a comparatively easy matter to follow the life cycles, but in the species which drop from the host to molt, as do most of our North American species, it is much more of a task. In these species we must succeed in getting the same individuals to attach to the host and catch them as they drop, three separate times. After dropping each time they must be confined under favorable conditions and frequent examinations made to determine the normal periods of molting and oviposition and the variations therefrom. These periods as well as the incubation period vary with the temperature. In order to present satisfactory information upon these periods, they should all be recorded in connection with the thermometric readings. Thus the following data should be recorded: locality bred, date of dropping or oviposition, date of molting or hatching, total period and total effective temperature. With such data at hand, information from studies in the South can be applied in the North.

The methods found the most satisfactory for the species attaching

to cattle is that suggested by Professor Lounsbury, of attaching a bag to the scrotum of a bovine. In this way the various stages of the ticks can be applied, examinations made and the ticks removed as they drop. All of the Ixodids thus applied by the writer have attached. Some species, however, *Dermacentor variabilis* in particular, attach with considerable reluctance. In this way by removing the bag and with it the unattached ticks at the end of a given period and then making examinations twice daily and removing the engorged ticks from the bag (which has been re-attached), the exact periods of engorgement can be determined. In order to prevent the removal of the bag from the scrotum, a harness has been arranged and will be found necessary.

In determining the life cycle of ticks that attach to small animals, such as dogs, rabbits, squirrels, fowls and others, the only satisfactory arrangement found has been a cage made of wire of about one fourth inch mesh, permitting the ticks to drop through into a pan beneath. This cage made of a wooden frame should have the joints set in white lead or putty in order to eliminate all possible hiding places, into which the ticks might crawl for protection. Nails inserted in the frame serve as good posts, preventing the ticks from crawling again to the cage. In the pan or tray under the cage may be placed strips of paper beneath which the ticks will crawl. It has been the practice to place a ring of white axle grease about the rim of the pan or tray to prevent the escape of any of the ticks which have dropped. Another way of preventing their escape is by setting this pan or tray in a larger one filled with water. When the examinations are made the tray can be removed, the ticks collected and the cage cleaned with little difficulty. The plan of this tray was first suggested to the writer by Professor Lounsbury and is similar to that which he has used.

Many ticks will molt when but a small amount of moisture is supplied, whereas others, as the species of the genus *Ixodes*, require much more. As the engorged ticks are removed from the bag or tray, it has been found that favorable conditions are furnished by placing them in pill boxes upon moist sand. These pill boxes are prepared by puncturing the tops and bottoms, or better yet, furnished with gauze tops, to permit of free circulation. Still more favorable conditions are furnished by inserting in sand test tubes from which the bottoms have been removed. As stoppers for the tubes, absorbent cotton will largely prevent too humid an atmosphere, if protected from rains. A large tray has been used filled with sand into which the tubes have been inserted and on which the pill boxes have been kept. By sub-irrigation the amount of moisture furnished can be kept nearly constant without interfering with the pill boxes. This sub-irrigation is best furnished by use of a large cylinder tube extending to the bottom of the

sand; water poured into this will gradually percolate through and moisten the sand.

For longevity experiments ticks are best kept in this way, observations being readily made through the glass without disturbing the ticks. These tubes may be kept outside inserted in the soil and the longevity of the stages determined under the prevailing or normal climatical conditions which, however, are not always the most favorable to longevity. In determining the longevity of ticks on grass and weeds, a screen cage is necessary to assure protection from accidental intrusion.

The life history of the Spinose Ear Tick, *Ornithodoros megnini*, has been determined by attaching to the ears of animals bags held in place and prevented from being rubbed off by tying to a cord about the horns.

SOME LIFE HISTORY NOTES ON THE SOUTHERN CATTLE TICK

(Illustrated with Lantern Slides.)

By E. C. Cotton, *Knoxville, Tenn.*

(Withdrawn for publication elsewhere.)

A TENTATIVE LAW RELATING TO THE INCUBATION OF THE EGGS OF MARGAROPUS ANNULATUS

By W. D. Hunter, *Bureau of Entomology, U. S. Department of Agriculture.*

Studies of the effects of temperatures upon insects have always held great interest and have frequently led to results of practical value. In this country the principal work has been done by Dr. L. O. Howard, who in 1896 in a paper read before this Association, "Some Temperature Effects on Household Insects,"[a] pointed out exactly how cold storage practice could be utilized in the control of certain species. A year before, the same entomologist had shown the probabilities of the restriction of imported injurious species to certain life zones which, of course, are predetermined by temperatures.[b] Later Doctor Howard in his paper on the geographical distribution of the yellow fever mosquito made much the most interesting and important contribution to the subject.[c] He showed how the range of *Stegomyia calopus* was determined by temperature and how the exact limitations of the regions in which this mosquito, if accidentally introduced, might be expected to become perfectly established, could be determined by computing the accumulated effective temperature.

[a]Bul. Bur. Ent. 6, p. 13–17. [b]Proc. Ent. Soc. Wash. 3: 219–226.
[c]Public Health Rep'ts, 18, No. 46.

The possibility of controlling Bruchids in stored cow-peas was shown in 1905 by Mr. J. W. T. Duvel.[e]

Prof. E. D. Sanderson in 1905 proposed a hypothesis regarding the determination of the time of maximum emergence from hibernation of the cotton boll weevil.[d] The proposed rule was based upon the departure of the temperature from the normal. The maximum emergence would be later or earlier than the normal time as the accumulated temperature would be lower or higher. The work on the boll weevil has furnished another example. Mr. W. O. Martin, formerly associated with Mr. Wilmon Newell, devised an ingenious method of determining the time when weevils in the dispersion movement had arrived in any certain field.[f] Previously it has been shown by Dr. W. E. Hinds and the writer that the growth of the weevil larva was regulated practically absolutely by effective temperatures and the amount of temperature necessary for the development of the different stages has been determined. Therefore the age of any weevil stage found in degrees of effective temperature was known. It only remained to sum up the daily effective temperature, going backward from the day upon which the specimens might be found until the total equalled the known amount necessary for that stage. The date thus obtained, of course, was the one upon which the parent weevil had reached the field.

There are two respects in which the cattle tick is conspicuously affected by temperatures: (1) its distribution in this country is limited; and (2) in a large portion of the natural range the eggs while not destroyed are prevented from hatching for several months during the winter. Attention was called by Doctor Howard to the restricted distribution of the tick and the close correspondence of its range to that of the yellow fever mosquito. In the present paper, however, we are concerned with the second feature, namely, the long deferred hatching due to low temperatures.

In work relating to the cattle tick, in which the writer is associated with Mr. W. A. Hooker, it was found that the total effective temperature required for hatching varied from 840 to 1510 degrees F. The shortest incubation period was found when the accumulated effective temperature was highest and the longest incubation when the accumulated effective temperature was lowest. That is, the incubation period varied inversely with the accumulated effective temperature. Now, obviously the reason for the variation is the daily mean temperature. In other words, incubation takes longer in winter than in summer. What was desired then was to determine the rela-

[d]Bul. Bur. Ent. 52, p. 29-42. [e]Bul. Bur. Ent. 54, p. 49-54.
[f]Cir. La. Crop Pest Comm. 9, p. 23-27.

tion between the daily mean temperature and the total effective required for hatching. An examination of careful records kept by Mr. Hooker extending over two entire years enables us to formulate the following tentative law: When the average daily mean temperature ranges less than 53.2 degrees, at least 1,510.8 degrees of effective temperature must accumulate before hatching will take place. When the mean daily temperature averages from 61.4° to 77.8°, from 840.5 to 1,139.1 degrees of effective temperature will be required for hatching. When the mean daily temperature averages higher than 80 degrees, between 782.7 and 824.3 degrees of effective temperature must be accumulated before hatching will take place.

Practical Application.—In approximately one-half of the normally tick infested area in this country no eggs deposited after about the middle of September hatch until some indefinite time the following spring. The cultivated fields (and those from which cattle have been kept for some time) in this large area are absolutely free of ticks every fall. Infested cattle will soon lose their ticks when placed on such areas and will not become reinfested with the progeny of the dropped individuals until such time as the eggs may hatch. The law proposed will tell the farmer how long the cattle may remain without danger of infestation. There has been an indefinite rule to let cattle remain in such cases "until spring," but some seasons they should be removed in February and in others the pasture could be continued in use until May. One of the most important difficulties in the rotation system of freeing cattle of ticks is that farms are generally overstocked. The rule proposed will tend to minimize this obstacle by showing how pastures may be utilized until the latest safe date.

The following is proposed as the most feasible plan in placing the necessary information in the hands of farmers: let the state entomologist keep records of the daily mean and effective temperatures (or obtain them from the Weather Bureau) beginning with, say September 15 and starting separate computations at regular semi-monthly intervals. These dates will stand for the time when any farmer may have placed cattle in tick free areas. When the proposed law shows that the time for eggs to hatch is approaching, notice could be issued in the press. Such a notice might read in brief as follows: Farmers who placed cattle in tick free areas between September 15 and 30 should remove them by February 15; there is no danger of reinfestation of cattle placed on tick free pastures during October and will not be until further notice is given.

It is not at all improbable that individual ranchers could apply the rule by means of data obtained on their own places. In such

cases, the results would be more exact because computations would begin on the exact date cattle were placed in the pastures, while those made in the office of the entomologist would necessarily be more or less generalized. The only apparatus necessary for the ranchman would be a set of maximum and minimum thermometers and the only work involved, the keeping of the record of the average daily mean temperature and the accumulated effective temperature from the date the cattle were placed on the tick free area.

Possible Criticisms.—The criticism might be made that studies referred to in the foregoing do not take into consideration factors other than temperature which might influence incubation. Among these might be mentioned: (1) moisture; and (2) accidental heat, as for instance from manure piles. Regarding moisture, it may be said that tick eggs are susceptible. A certain degree of dessication absolutely prevents hatching. Nevertheless our data have been drawn from eggs placed under a variety of conditions and due allowance has been made in the law for the usual seasonal variations. Our figures are not from individual lots of eggs, but averages from many lots under different conditions. The accidental heat from manure referred to at most could be but an exceedingly unimportant matter. About barns it might be worthy of consideration, but in pastures for all practical purposes it would be absolutely negligible.

There is a margin for possible error in the temperatures that may occur between the time a prediction is made and the actual time of hatching. Unusual variations may lengthen or shorten this interval. This obviously will always make it impossible to predict the exact time of hatching. Nevertheless, close approximations can be made and these will serve every practical purpose. The entomologist can always take pains to be on the safe side by allowing for the highest temperatures known for the period between the date of the prediction and the forecasted date of hatching.

In conclusion, it seems that the present proposed law is at least as tangible as any temperature law proposed with reference to insects. Strictly tentative as it is and subject to possible important modifications or even absolute nullification as the result of further data, at this time it seems to have practical possibilities. Though not as important as Doctor Howard's rule regarding the yellow fever mosquito, it is at least as definite, for the factors that could possibly vitiate it are no more important than in that case. On the other hand the law cannot be as exact as Wallich's rule governing the hatching of fish eggs, because in that case all the varying influences of the air are absent and replaced by less important ones in the water.

The law dealt with in this paper was given preliminary notice in

bulletin 72, Bureau of Entomology, U. S. Department of Agriculture, page 20. Much additional data has been obtained since the publication of that bulletin. The work is being continued and further results will be recorded from time to time.

In discussing these papers Mr. Hooker called attention to the lantern slides exhibited by Mr. Cotton, which showed the large number of eggs deposited by the North American Fever Tick. This holds true with all Ixodid ticks, as they literally manufacture eggs from the blood with which they become engorged. Comparatively few of the seed ticks find a host, the majority dying from starvation, otherwise all animal life would be covered with ticks. The largest ticks belong to the genus *Amblyomma*. The gulf coast tick, *Amblyomma maculatum*, is the largest found in this country and when fully engorged the female measures three fourth of an inch in length. He had counted 11,265 eggs that had been deposited by a single tick of this species. The bont tick, *Amblyomma hebraeum*, of South Africa reaches an inch in length when fully engorged and Prof. Lounsbury estimates that a single female will deposit 20,000 eggs.

Mr. Sherman called attention to the excellent work that is being done in North Carolina by the state veterinarian, Dr. Butler. By utilizing the known facts concerning the cattle tick, twenty counties had been freed from quarantine.

Mr. J. L. Phillips remarked that conditions in Virginia are quite similar to those in North Carolina and that the quarantine line is being pushed south very rapidly.

Mr. W. D. Hunter testified to the valuable work that is being done by Dr. Butler in North Carolina, but called attention to the delicate equilibrium in which this species exists in the northern range. The problem is more difficult further south, as in Texas, where the ticks persist all winter.

Dr. Howard remarked that the Texas cattle tick is a tropical and lower austral species and that it can undoubtedly be controlled more easily when outside its normal range.

Mr. Sherman said that probably the results would be more slowly accomplished in the southern part of the state, nevertheless he considered that the results secured were exceedingly encouraging.

A paper was presented by Mr. Sanderson:

THE RELATION OF TEMPERATURE TO THE HIBERNATION OF INSECTS

By E. D. Sanderson, *Durham, N. H.*

Three years ago at the Philadelphia meeting of this association the writer advanced a hypothesis for determining the time of maximum emergence of the Mexican cotton boll weevil. Subsequent observations by others have tended to discredit the correctness of the method then advanced, but it served to call attention to the fact that "the time of emergence of insects from hibernation and the date upon which they begin oviposition or normal activity is dependent upon well-defined physical laws" which should be determined, and the writer is of the opinion that careful study of the large amount of data now accumulating concerning the time of emergence of the boll weevil will reveal the laws governing the time of its appearance.

Since then, with the aid of assistants and students, I have made a number of experiments principally with the tent caterpillar (*Malacosoma americana*), the brown-tail moth (*Euproctis chrysorrhoea*), and the codling moth (*Carpocapsa pomonella*), in an endeavor to determine the relation of temperature to the hibernation of insects. Only a beginning has been made and as we get deeper into the subject we find that it is an exceedingly complex one and is closely bound up with fundamental problems of physiology and heredity. There are a few points, however, which may well be brought to your attention at this time.

It has been customary in the study of meteorological and biological data concerning temperature to use the mean daily temperature in accumulating the amount of temperature involved in any phenomena. But it is evident that if the day be cloudy and the sun shine for a short time at noon that the mean for that day will be much higher than the actual mean temperature which occurred during that day. We have therefore resorted to the use of recording thermographs of the Reichard or Short and Mason type, such as are in use by the U. S. Weather Bureau, which, with frequent standardization, show the actual temperature for the whole day. The polygon covering the temperature for the day is then measured with a polar planimeter and the actual mean temperature for the day is thus secured. It is found that frequently a difference of ten degrees occurs in greenhouses between the mean secured from the maximum and minimum and the true mean thus secured with a thermograph. Such records are especially important where a glass house is being used for experiments, and it would seem that this is the only accurate method of recording temperature where an exact study of temperature is desired for bio-

logical work, if not indeed for meteorological studies. The weekly sheets are readily filed and the temperature which occurred at any time during breeding experiments can thus be readily referred to or computed in the future.

We have been endeavoring to determine whether there be a "thermal constant" which governs the emergence of insects from hibernation. The "thermal constant" for insects may be defined as *that accumulation of mean daily temperature above the "critical point" of the species, which will cause it to emerge from hibernation or to transform from any given stage.* The "critical point" above which the temperature is accumulated is a matter of vital importance and seems to have been largely neglected in entomological work. European botanists have established the critical points of a long list of plants and shown that a large variation exists between species.[a] The "critical point" may be defined as that point of temperature above which active metabolism occurs and above which the accumulation of temperature affects the time of definite transformations in the organism, such as the leafing and flowering of plants, and the emergence from hibernation, hatching and transformations of insects. In recent studies of the relation of temperature to insect life it has been assumed that all temperatures over 43° F. are "effective temperatures," or that 43° F. is the critical point. But the records based upon this assumption go to prove that the critical point varies and that it must be determined for each species before accurate conclusions concerning the relation of temperature to that species can be secured. Thus, as was pointed out by Simpson in his excellent studies of the Codling Moth, it was impossible for him to draw definite conclusions from a considerable mass of data published by him concerning the influence of temperature upon the duration of its various stages.[b] The same fact has been brought out by Hunter and Hooker in their recent paper on the North American Fever Tick in their study of the relation of temperature to the period of incubation.[c] In the case of the browntail moth, our present observations go to show that 34° F. is the critical point above which the temperature accumulates in determining the time of emergence in the spring. The critical point is doubtless much lower for northern species and much higher for southern species, and it seems quite probable that it may vary for the same species which has become acclimated to diverse climatic conditions. Thus the

[a]See Cleveland Abbe, First Report on the Relations Between Climates and Crops, Bulletin 36, U. S. Weather Bureau, 1905.

[b]See Simpson, Bulletin 41, Division of Entomology, Tables IV and V, pages 37–39.

[c]Hunter and Hooker, Bulletin 72, Bureau of Entomology, page 20.

tent caterpillar has but one generation both in the North and South, hibernating over winter in the egg, in which the larva is completely formed. The critical point must be much higher in the South, for the low temperatures which are effective in the North are rarely reached in the South.

The time at which insects enter hibernation in the fall is undoubtedly largely influenced by temperature, and in many species it may be the controlling factor, but there are many cases where hibernation commences before there is a material drop in temperature, and that the lowering temperature is the controlling factor is disproved by the fact that insects subjected to high temperatures before the normal time for hibernation persist in hibernating or else remain slightly active, but rest and do not feed or reproduce for a considerable length of time. This has been shown by Tower in his remarkable experiments upon the Potato Beetle and in our own experiments. This paper of Dr. Tower[d] will ever remain an entomological classic and should receive the study of everyone interested in economic entomology. Tower has shown that all of the beetles of this genus have two generations and no more, and that after the second generation there must be a time of rest before reproduction continues. In some cases this is hibernation and in others æstivation, which Tower maintains are practically the same as regards the life history of the insect. In both cases the insect prepares for the resting stage by losing about 30% of its gross weight through the loss of water, which enables it to withstand a lower freezing point and higher temperatures than if the protoplasm were not thus condensed.

In endeavoring to determine the thermal constant for emergence we have placed the hibernating stage in greenhouses heated at different temperatures and compared the amount of temperature accumulated in each up to emergence with that accumulating in nature. The first year the insects were not placed in the greenhouse until in January, after they had been subjected to considerable cold weather. They emerged in due time in a fairly normal manner. In 1906 the insects were brought into the greenhouse earlier in the season before they had been subjected to much cold out of doors. As a result it required much more heat over a longer period to force their emergence and they emerged irregularly for several weeks. Lots brought in later in the winter emerged much more normally. We were therefore led to suspect that the cold of winter had a positive influence in determining the length of the hibernation of these insects, which subse-

[d]W. L. Tower, Evolution in Chrysomelid Beetles of the Genus Leptinotarsa. Carnegie Institution, No. 48. 1906.

quent experiments have proven to be true. This fall we placed several lots in an icehouse and in cold storage for various lengths of time during August and September, at the same time placing other lots in glasshouses, where they never were subject to low temperatures. Those which were placed in cold storage have hatched, in the case of the tent caterpillar eggs in about two weeks, while those which have not been subjected to cold have not hatched yet. Several lots placed in storage and taken out at different times have proven this, and our experiments are arranged to show how long they must be subjected to low temperature and whether extreme low temperatures have any more effect or will reduce the time of hibernation more than those merely below the critical point. This fact had been previously shown by Weismann in his paper, "On the Seasonal Dimorphism of Butterflies" nearly thirty years ago,[e] when he described experiments in which by subjecting pupæ of the summer form of *Pieris napi* to refrigeration for three months and then bringing them into a hothouse he was able to secure the winter form by about October first, but in which he was unable to secure the immediate transformation of pupæ of the fourth brood of *Araschnia levana* (*prorsa*) by placing them in a hothouse as soon as the pupæ formed, for invariably nearly all hibernated over winter, even in the warm hothouse, and emerged in the spring as the winter form. It is evident that subjecting these hibernating forms to low temperatures has the effect of producing a more complete rest than when hibernation goes on at higher temperatures, and the time of hibernation may therefore be shortened in many instances by subjecting to cold before heat. It is interesting to note in this connection that the same effect as that normally sustained by freezing has recently been secured with rhubarb, various bulbs, lilac and other flowering plants, by anesthetizing them with ether. The exact effect of the ether has not been definitely determined, as far as I can ascertain from a cursory examination of the literature, but Dr. Loeb[f] has suggested that the effect is possibly related to the effect of cold upon chrysalids as mentioned above. If the effect of the ether is a drying process, as some claim, this seems possible.

In the light of these facts, may it not be possible to account for the fact that some insects have but a single generation in the South, while others have several generations? Thus the tent caterpillar, peach borer, plum curculio, canker worms, gypsy and brown-tail moths, and others, mostly insects affecting native fruits and seemingly indigenous

[e] August Weismann. Studies in the Theory of Descent, translated by Meldola. Eng. Ed. London, 1882.

[f] Loeb—The Dynamics of Living Matter. 1906, page 112.

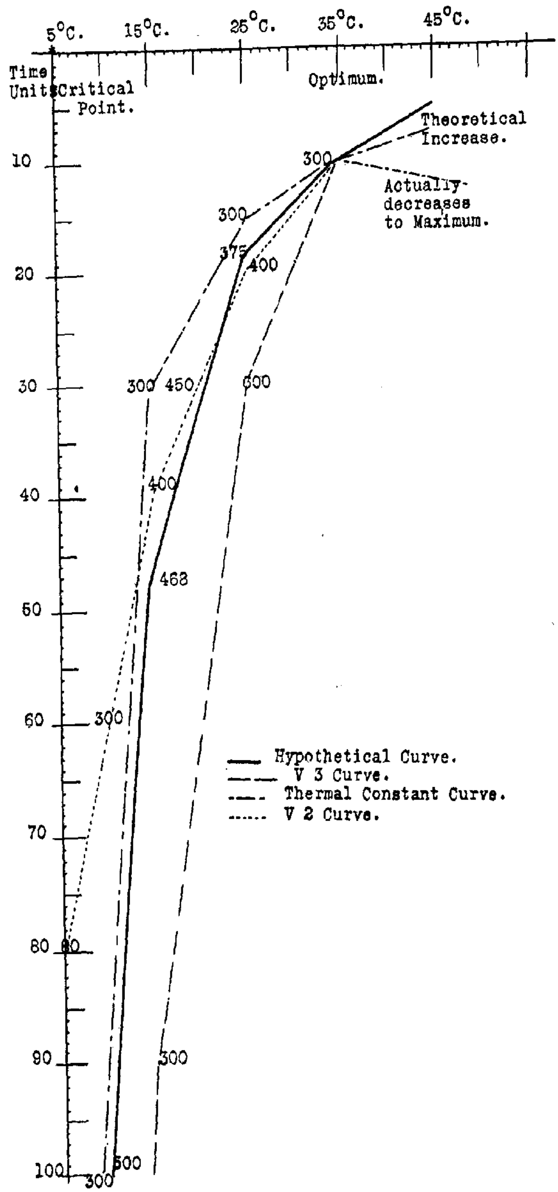

FIGURE 1. Caption on opposite page.

to north temperate climates, have but one generation in the South, while southern species have many generations in the South, but the number decreases as they spread northward. Why should not all have several generations in the South? I have been unable to find any investigations of this problem whatever and would be indebted for any data which will throw any light upon it.

In some cases, however, the time of emergence from hibernation is controlled by moisture conditions as well as temperature, or independent of temperature. Thus Tower kept the potato beetle in hibernation for 18 months at a high temperature but with a dry atmosphere, and they emerged as soon as normal moisture conditions were produced. Webster and Hopkins have shown a similar effect of lack of rainfall on the emergence of the Hessian Fly in the fall. In relation to hibernation in humid climates the matter of moisture is probably not a controlling factor, but undoubtedly has the most important influence upon the time of emergence of forms in æstivation during the summer or in arid regions.

A principle which should be considered in any attempt to fix a thermal constant is the law of the velocity of chemical reactions. In general, it may be stated that the velocity of chemical reactions doubles or triples with every increase of 10° C., or in other words, a reaction will take but one half or one third as much time with an increase of 10° C. The application of this law to the velocity of various phases of the physiology of animal and plant life is receiving considerable attention by physiologists at the present time and some of the observations made are shown graphically in figure 2. But all of the observations made go to show that this so-called law is only an approximation of the facts between certain degrees of temperature ranging within 15° or 20° C. of the optimum temperature of the form under study. At low temperatures the velocity rises very rapidly as temperature increases, and above the optimum the velocity decreases. The difference between the observed change in coefficient of increase of velocity as temperature rises, as shown by these curves, and the theoretical application of this law if the velocity doubled or tripled with every increase of 10° C. is shown by the difference be-

FIGURE 1. Curves showing the relation of increase of temperature to the time required for stages of growth of animals, more particularly as affecting the emergence from hibernation and transformations of insects. *Hypothetical Curve*, indicating the empirical nature of the curve of effect of temperature of individual species; *V 2 and V 3 Curves* based on uniform coefficient of increase of velocity of reaction of 2 and 3; *Thermal Constant Curve*, based on thermal constant of 300°C. Numbers on curves are the thermal constants in degrees Centigrade at points marked. Optimum of 35°C. is empirical and varies for each species.

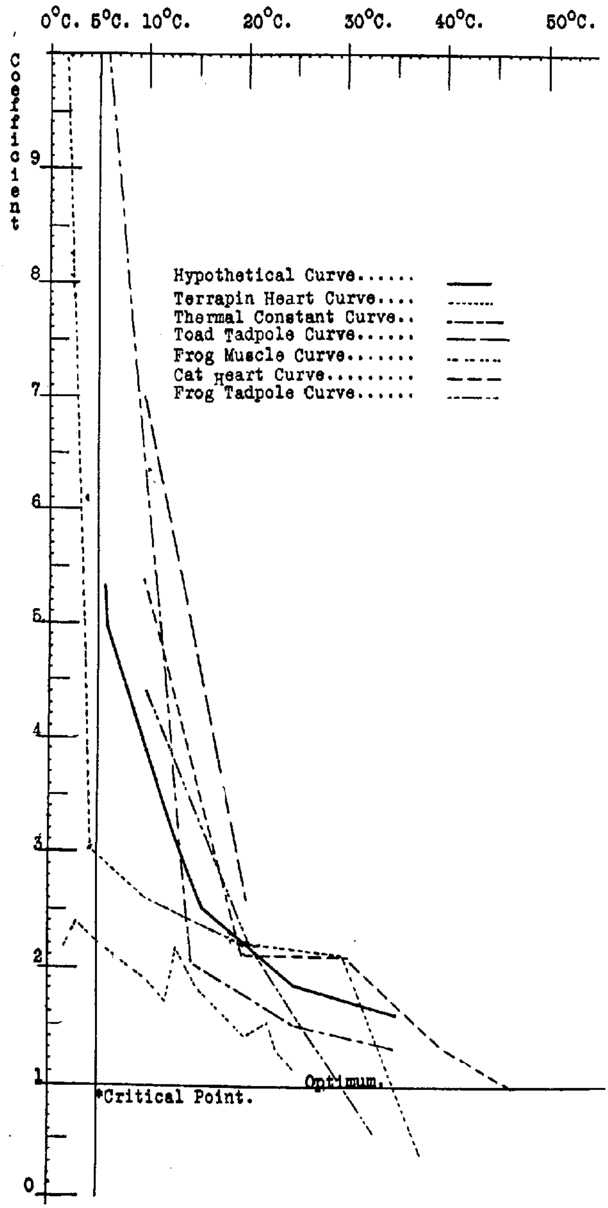

FIGURE 2. Caption on opposite page.

tween these curves and a horizontal line at 2 or 3, which would represent the plotting of the increase of velocity, were it uniform between the critical point and maximum.

If there be a thermal constant for all temperatures between the critical point and maximum, it would be represented by a curve like "T. C. C." in figure 1. But there is evidence to show that the thermal constant is lower at the optimum than at temperatures approaching the critical point. And if the velocity be plotted from the curve "T. C. C." of figure 1, the same curve in figure 2 shows that the coefficient of increase of velocity with a uniform thermal constant is much less than that observed, being only 1.5 at 25° C. On the other hand, if we plot a curve based on a uniform increase of velocity of a coefficient of 2 or 3 we secure curves V2.C. and V3.C. of figure 1, respectively, and by computing the thermal constant for various temperatures on these curves, it is found that the thermal constant increases below the optimum to a certain point and then decreases. Thus on V2.C. the thermal constant at 35° is 300, at 25° is 400, at 20° is 450, and then decreases to 400 again at 15°, to 300 at 10°, and at the critical point we secure the anomaly of a thermal constant of 80°, which is clearly impossible, as no reaction will take place unless above the critical point. The same would hold true of curve V3., or any other curve based upon a uniform coefficient of increase of velocity.

From a study of these considerations it seems probable that the effect of temperature upon various forms of animal life will be represented by a curve characteristic for each species or group for the various phenomena of growth considered, and that such a curve will be between the curve shown in figure 1 for the uniform thermal constant, T. C. C., and that for a uniform rate of increasing velocity, V2.C. Such a curve may be secured by a uniform coefficient of increase for the thermal constant as the temperature decreases from the optimum as shown in curve H. C.—hypothetical curve—figure 1.

FIGURE 2. Curves showing variation of coefficient of velocity of certain biological phenomena. *Hypothetical Curve*, based on same in figure 1; *Terrapin Heart Curve*, based on rate of heart beat of Pacific terrapin, from data by Snyder[a]; *Thermal Constant Curve*, based on same in figure 1; *Toad and Frog Tadpole Curves*, based on rate of growth of toad and frog tadpoles from data of Lillie and Knowlton[b]; *Frog Muscle Curve*, based on rate of contraction of gastrocnemius muscle of frog from data of Burnett[c]; *Cat Heart Curve*, based on rate of beat of isolated cat hearts from data of Langendorff[d].

[a] Snyder, Univ. Calif. Publications, Physiology, 2, pp 125. 1905, quoted by Arrhenius, Immunochemistry, pp 139.

[b] Quoted by Morgan, Experimental Zoology, pp 260.

[c] Burnett, Jour. Biological Chemistry, 2, pp 200-1906.

[d] From Snyder, Amer. Journal Physiology, 17, pp 356-1906.

In this curve the thermal constant has been increased 25% for every decrease of 10° from the optimum or with a uniform coefficient of 1.25. Upon plotting this curve it is found that the thermal constant increases uniformly toward the critical point, but that it would approach the critical point to infinity. Upon plotting the curve of the coefficients of increase of velocity of such a curve, the curve H. C. of figure 2 is secured, which corresponds very closely with those secured from actual observations.

But if there be such an empirical temperature curve for each species or phenomenon, it is evident that there can be no thermal constant which will be constant at all temperatures, for it increases in a uniform ratio below the optimum. A constant may however be secured by reducing the increments of temperature for each unit of time to terms of the thermal constant at the optimum, which is therefore 1. Thus the values of one unit of time on the hypothetical curve, H. C., figure 1, would be 0.1 at 35°, the optimum, 0.056 at 25°, and 0.021 at 15°, etc. When by adding these values sufficient are secured to make 1, the thermal constant has been reached, equivalent to the thermal constant at the optimum temperature. To secure such values it would be necessary to secure the thermal constant at the optimum and at two or three constant temperatures below, upon which the curve of the species or phenomenon might be plotted and the values for each degree of temperature for one unit of time calculated.

At present this is, of course, largely a hypothesis, but it accords with all the facts which have come under our observation, and seems worthy of attention by those who are engaged in study of the relation of temperature to insect life; for without hypotheses what could we accomplish in such work? During the coming year we hope to definitely determine this matter by rearing large numbers of two or three common household pests in specially constructed apparatus which will maintain constant temperatures, and thus enable us to secure the thermal constants for various temperatures, which may then be compared with the amount of temperature accumulated with varying temperatures.

It may seem to some that such studies are of rather remote importance to practical economic entomology, but as such work accumulates it becomes more and more evident that a positive knowledge of these fundamental factors governing the life of insects may have great practical value, and that entomology, as well as all biological science, must consider its relations to the more exact and fundamental sciences of physics and chemistry, if we are to have exact knowledge of the life with which we are dealing. Hunter and Hooker have recently suggested the practical application of such work in their study

of the relation of temperature to the incubation of eggs of the cattle tick and it seems probable that a similar application might be made in determining the time of treatment of the codling moth, though it is hardly probable that it will be necessary in the latter case.

But it is upon a positive and not merely hypothetical knowledge of such controlling forces as temperature that our science must rest and no one can foresee what entirely practical application may be made of it in the future study of new pests as they present themselves for study under new conditions.

The remainder of the proceedings of the 20th meeting of the Association of Economic Entomologists will be given in the next number of the Journal. It has been deemed advisable, in view of its close relation to two papers in this number, to publish at the same time Mr. Hooker's summarized account of our knowledge of the role of ticks in the transmission of disease. The paper was prepared originally for presentation at the meeting and as a part of the symposium on ticks, consequently it is very fitting that it should appear at this time.

A REVIEW OF THE PRESENT KNOWLEDGE OF THE ROLE OF TICKS IN THE TRANSMISSION OF DISEASE*

By W. A. Hooker, *Bureau of Entomology, U. S. Department of Agriculture.*

Not until within the last decade has the importance of insects and related animals as agents in the transmission of disease been fully appreciated. Within this period, however, the progress of our learning has advanced at an astounding rate. It was but fifteen years ago that Smith and Kilborne first demonstrated the role that the cattle tick, *Margaropus* (=*Boophilus*) *annulatus*, plays in the transmission of Splenetic or Texas Fever of Cattle, and only ten years ago that Ross first employed *Anopheles* in his mosquito-malaria experiments. To-day we all know of the mechanical and biological agency of the flies and mosquitoes in the transmission of typhoid fever, cholera, anthrax or charbon, nagana or tsetse-fly disease, surra, malaria, yellow fever, filiariasis and dengue, and of fleas in the transmision of bubonic plague. Together and with the investigation of the Bacteriologist and Protozoölogist has come that of the Entomologist in the study of the life history and habits of the disease-carrying insects. We are all acquainted with the investigations in this country of Dr. L. O. Howard,

*Prepared for presentation at the meeting of the Association of Economic Entomologists, held at Chicago, Illinois, Dec. 27-28, 1907.

Dr. J. B. Smith, Dr. E. P. Felt and others, supported by federal and state appropriations, making preventive treatment possible.

But it is to the *Ixodoidea*, or ticks, that I wish to call your attention in a brief review of our present knowledge of their role in the transmission of disease and to show that they are equally as imporant as the flies and mosquitoes in the transmission of disease. The object in preparing this paper is to emphasize the importance of the study of their biology and to encourage a more extensive collection of them by the Entomologist, within whose field of study they distinctly come.

That the importance of the investigations of the Entomologist are appreciated by the medical profession is well shown by the following paragraph taken from an address before the London School of Tropical Medicine by Sir Lauder Brunton,[1a] M. D., upon "Fleas as a National Danger," namely: "What is true of the G. *(lossina) palpalis* is true of other flies also, and as ticks and bugs are likewise most important as carriers of diseases there really ought to be established by government a chair, or, still better, an institute of scientific entomology, well endowed and having attached to it a number of men who could carry on original investigations. Such a chair, or institute, if thoroughly well endowed and having money lavishly expended upon it, would repay the expenditure a thousand-fold, for the study of tropical diseases is becoming to a great extent identified with the study of the insects which transmit them."

Professor C. P. Lounsbury, Government Entomologist of Cape Colony, may well be considered the pioneer in the study of the biology of the ticks. Prior to 1898, at which time he commenced their study, with the exception of the cattle tick, *Margaropus* (=*Boophilus*) *annulatus,* but little was known of their life history and habits. In speaking of their importance and of the opportunities offered in the study of this group, in a paper read before the British Association for the Advancement of Science[2] in 1905, he said, "To my mind the ticks present the more profitable field for the student, whether he be interested in the systematic classification of the species, in the determination of habits and metamorphoses, in experimental research in regard to their transmission of diseases, or in the development of pathogenic organisms within the body of intermediate hosts." In reviewing the status of our knowledge he said, "An excellent groundwork for the classification of the species has been made by Professor G. Newman in his *Revision de la famille des Ixodides,* which has been published in several parts by the Zoölogical Society of France during the last ten years; but very little has thus far been recorded on the internal anatomy of

[a]The numerals refer to bibliographical references at end of paper.

any species (for later work see following paragraphs), and so far as I am aware no one has yet traced the development of a disease organism within the body of a tick as has been so ably done in the somewhat analogous case of malarial organisms in *Anopheles* mosquitoes. Also very little has been recorded in regard to the habits and metamorphoses of any species other than those of the genus *Boophilus.*"

Since 1905, however, several valuable contributions have been added, including one upon the internal anatomy of *Margaropus annulatus* by S. R. Williams[4] and by W. E. Allen.[5] Mr. Nathan Banks of the Bureau of Entomology now has in manuscript a revision of the ticks of this country, which, when issued, will greatly aid in identification. Koch[6] has elucidated much of the life cycle of *Piroplasma bigeminum,* the cause of splenetic or Texas fever, and has succeeded in discovering the first stages of development of *Piroplasma parvum,* the parasite of African Coast fever, which are undergone in the tick. Christophers,[7] also Nuttall and Graham-Smith,[8] have followed the complete life cycle of *Piroplasma canis,* the cause of malignant jaundice of dogs.

Doctors Smith and Kilborne,[9] discovering in 1892 the role that the cattle tick, *Margaropus* (=*Boophilus*) *annulatus,* plays in the transmission of the protozoan, *Piroplasma bigeminum,* the blood parasite causing Texas fever of cattle in this country, paved the way for this new field of investigation. Since that time a number of diseases of man and the domestic animals have been found to be transmitted by these parasites. Subsequent investigation has shown that ticks are the intermediate hosts of species belonging to the disease producing protozoan genus *Piroplasma.* It has also been shown that several diseases produced by spirochaetæ are transmitted by ticks. The conclusions reached by Dutton and Todd[10] are that some development of the spirochaetæ of human tick fever takes place in the tick. Koch has found the spirochaetæ to multiply within the egg. Borrel and Marchoux[11] have found the spirochaetæ[b] of fowls to develop at 35° C. in the body of the tick.

In order to show the zoölogical position of these blood parasites (*Piroplasma*) transmitted by ticks, the following table taken partially from Daniels and Stanton's[12] most excellent work, is given:

[b]There is still a difference of opinion as to the structure and relations of the spirilla and spirochaetæ. They have many similar characters but differ (according to some authors), the latter having flagellæ, which place them across the imaginary line from the former into the protozoa, thus being considered as animal life, while the spirilla are bacteria (or lowly organized plants.) Dr. Raphael Blanchard in the Revue Vétérinaire, 1906, p. 86, places all that are pathogenic in the genus Spirochaeta.

The exact position of some of the spirochaetæ is in question at present but they are believed to belong to the *Mastigophora.*

It seems probable that blood parasites exist in certain hosts without ill effect, such animals being naturally immune or having acquired immunity. When these organisms are transmitted to the blood of susceptible hosts, however, as are the various species of *Piroplasma,* a disease of more or less severity results. This is the case with the trypanosome of tsetse-fly disease, which Koch has found to be transmitted from the crocodile to man by the tsetse-fly (*Glossina* spp.). Again, while the organism producing Rocky Mountain spotted fever has not been discovered, yet Dr. H. T. Ricketts[13] has produced the disease in guinea pigs by ticks from horses, cows and vegetation and suspects its transmission from the blood of some animal which has served as host.

TABLE SHOWING THE ZOÖLOGICAL POSITION OF THE TICK TRANSMITTED PARASITES, PIROPLASMA SPP.

PROTOZOA.

- Class (1) *Rhizopoda* (*Sarcodina*)
- Class (2) *Mastigophora* Probably includes the Spirochaetae transmitted by the Argasid ticks as well as the Trypanosomes transmitted by flies of genus *Glossina*
- Class (3) *Sporozoa*
  - Sub Class *Telosporidia*
    - Order (1) *Gregarinoidea*
    - Order (2) *Haemosporidia*
      - Genera
        - (1) *Plasmodium* (*Haemamoeba*) Including the malarial parasites transmitted by mosquitoes, of the genus *Anopheles*
        - (2) *Haemogregarina*
        - (3) *Piroplasma*
          - *P. bigeminum*
          - *P. parvum*
          - *P. ovis*
          - *P. equi*
          - *P. canis*
          - etc.

          Transmitted by the Ixodinid ticks
        - (4) *Halteridium* (?)
    - Order (3) *Coccidiidea*
  - Sub Class *Neosporidia*
- Class (4) *Infusoria*

THE FOLLOWING TABLE, AS ADAPTED FROM SEVERAL AUTHORS, SHOWS THE ZOÖLOGICAL POSITION OF THE TICKS.

SUB KINGDOM OR PHYLUM: ARTHROPODA

Class (1) *Onychophora* (2) *Myriapoda* (centipedes, millipedes, etc.) (3) *Insecta* (flies, mosquitos, gnats, fleas, etc.) (4) *Arachnida* (5) *Crustacea* crabs, lobsters, etc.)

Order (1) *Araneida* (spiders) (2) *Pedipalpida* (whip scorpions) (3) *Scorpionida* scorpions) (4) *Pseudoscorpionda* (book scorpions) (5) *Opilionda* or *Phalangida* (6) *Solpugida* (7) *Acarida* (mites, ticks)

Super Family (1) *Demodicoidea* (mites of the hair follicles) (2) *Ixodoidea* (ticks) (3) *Gamasoidea* (mites on beetles and other insects) (4) *Oribatoidea* (beetle like mites) (5) *Hydrachnoidea* (water mites) (6) *Sarcoptoidea* (itch mites) (7) *Eupodoidea* (the primitive mites) (8) *Trombidoidea* (running mites)

Family (1) *Argasidae*
Genus *Argas*
" *Ornithodoros*
(ticks which transmit Spirochaete and Spirillum (?)

(2) *Ixodidae*

Sub Family (1) *Rhipicephalinae*
Genus *Rhipicephalus*
" *Margaropus*
" *Haemaphysalis*
" *Dermacentor*

(2) *Ixodinae*
Genus *Ixodes*
" *Amblyomma*
" *Hyalomma*
" *Ceratixodes*
" *Aponomma*

(ticks which transmit *Piroplasma* spp)

Professor Lounsbury commenced the study of ticks in 1898. He first determined that heartwater,[c] a disease in that country of sheep, goats and cattle, which often proves fatal, is transmitted by the Bont Tick, *Amblyomma hebraeum.* The stimulus from this discovery has resulted in the determination that several diseases of animals in South Africa, besides red water or Texas fever, are thus transmitted, including malignant jaundice of dogs, African coast fever of cattle, and biliary fever of horses, mules and donkeys. Not only has it been demonstrated that these diseases are transmitted by ticks, but the species and the stages of each that are carriers of the pathogenic organisms have been determined.

The cattle tick of this country, *Margaropus* (=*Boophilus*) *annulatus*, now known as the North American Fever Tick, and its varieties found in other countries, all transmit *Piroplasma bigeminum.* In Europe, however, the European Castor Bean Tick, *Ixodes ricinus,* a species also found in this country, has been found to transmit the disease, imbibing the infection as an adult and transmitting it in the larval and nymphal stages following. As is generally known, the larva of the North American Fever Tick transmits the disease to susceptible animals when the previous generation has imbibed the infection, thus passing through the egg.

Lounsbury has found that in heartwater but one species, *Amblyomma hebraeum,* the Bont Tick, is concerned; as a larva it feeds on an infested animal, transmitting the disease in both nymphal and adult stages to a susceptible animal. The infection does not pass through the egg as with splenetic fever.

Malignant jaundice was found by Lounsbury to be transmitted from one dog to another by the Dog Tick, *Haemaphysalis leachi.* The infection is not transmitted by the larva or nymph, but by the adult alone and only when the adult of the preceding generation imbibed infectious blood. Ten was the smallest number of ticks that produced the disease in Lounsbury's experiments, although he concludes that a single pathogenic tick is probably ample to communicate infection that may lead to death. Christophers has found this disease in Madras, India, to be transmitted by *Rhipicephalus sanguineus,* and has followed the life cycle of the parasite, *Piroplasma canis.* Daniels and Stanton state that *Dermacentor reticulatus* transmits the disease in Europe, but I have not seen such record.

African coast fever, an extremely fatal disease of cattle in South

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[c]In Cape Colony whole strips of country have become almost useless for sheep and goat breeding, as have certain districts in the Transvaal, due to heartwater.

Africa, was at first (1903) thought by Lounsbury to be transmitted by the Brown Tick, *Rhipicephalus appendiculatus*, alone, but further investigation has proven that four other species of the genus, *simus, evertsi, nitens* and *capensis* may also transmit it. The Brown Tick imbibes the infection as a larva or nymph and transmits it in the following stage of the same generation. In the adult stage both sexes transmit the disease, but one or two specimens being necessary. The infection does not pass through the egg.

Dr. Arnold Theiler,[14] Government Bacteriologist of the Transvaal, has found biliary fever or piroplasmosis of horses, mules and donkeys to be transmitted by the Red-legged tick, *Rhipicephalus evertsi*, one of the species found by Lounsbury to transmit African coast fever. The infection is imbibed as a nymph and transmitted by the adult. Doctor Theiler[15] also seems to have shown that spirillosis of cattle in South Africa is transmitted by *Margaropus decoloratus*. Koch has since found cases of this spirillosis in Daressalem, German East Africa, and has succeeded in tracing the spirochaetæ to within the eggs of the ticks.

To Doctors Marchoux and Salimbeni[16] belongs the credit of first demonstrating that a tick transmits a spirochaetæ. In 1903 they published a report of their studies, showing that the Fowl Tick, *Argas miniatus*, is an agent in the transmission of spirillosis in fowls at Rio Janeiro, Brazil. The disease seems to be transmissible by the innoculation of infectious blood. While the tick is one agent, the disease may also be transmitted by feeding blood or excrement of diseased fowls, thus it does not seem that the spirochaetæ is necessarily dependent biologically upon the tick. Balfour[17] has found what appears to be the same disease of fowls in the Soudan of Africa, and Reaney[18] that it is endemic in Central India.

Motas[19] has shown that *Rhipicephalus bursa* transmits carceag or ovine piroplasmosis in Europe. This tick passes the larval and nymphal stages upon the same animal, but drops to the ground for the second molt. The infection (as is the case of *Haemaphysalis leachi*) is transmitted by the adult, when the adult of the previous generation has fed upon an infectious host, and not by the larva or nymph.

Kossel[20] and associated investigators have demonstrated that piroplasmosis of cattle in Europe is transmitted by *Ixodes ricinus*. This tick drops for both molts, the larva and nymph being pathogenic. This is of importance, as it may be found to do the same in this country.

In 1905 Dutton and Todd[10] published an account of their study of the so-called human tick fever in Congo Free State. They found it to be produced by a spirochaetæ that has since been determined by

Breinl and Kinghorn[21] to be new to science and described as *Spirillum duttoni.* This spirochaetæ can be transmitted from animal to animal by the bite of the Tampan Tick, *Ornithodoros savignyi* var. *caecus* (=*moubata*). In the experiments of Dutton and Todd, rabbits, guinea pigs, rats and monkeys were used. The infection was found to pass through the egg. Koch[6] working independently in German East Africa in 1904 made the same discovery. He found the spirochaetæ to multiply within the egg and that the young ticks from infected localities are capable of infecting monkeys.

Skinner[22] states it his belief that the ticks common on rats in India transmit the plague bacillus.

The connection between ticks and Rocky Mountain spotted fever of man in this country has been the subject of considerable investigation. Dr. H. T. Ricketts[23] of Chicago and Dr. W. W. King[24] of the United States Public Health and Marine Hospital Service have succeeded in transmitting the disease from one guinea pig to another by the application of *Dermacentor occidentalis.* Later, Doctor Ricketts has produced the disease in a guinea pig through the attachment of 36 males which were collected partly from horses and cows and partly from the vegetation in the vicinity where the disease occurs. This seems to prove that the tick is the natural transmitter of the disease.

For some time it was thought that louping ill, a disease of sheep in Scotland, was transmitted by the European Castor Bean Tick, *Ixodes ricinus,* but Wheler[25] recently states that this apparently has been disproven.

Modder[26] states his belief that the yaws of paranghi disease of man and cattle in Ceylon, which is produced by a spirochaete, is transmitted by a tick. Bettencourt, Franca and Borges[27] have described from a deer in a park at Mafra, Portugal, a bacilliform plasma which they believe to be introduced into Europe by ticks from zebus in the park.

Laveran and Nègre[28] suggest the possible transmission of a disease in an African land turtle, due to a Haemagregarine, by the Bont Leg Tick (*Hyalomma aegyptium.*)

In this country Professor H. A. Morgan[29] has studied several species and has determined that neither *Dermacentor variabilis* nor *Amblyomma americanum* transmit splenetic or Texas fever. Dr. N. S. Mayo[30] has reached the same conclusion with the latter species.

Aside from splenetic or Texas fever and Rocky Mountain spotted fever, no disease in this country has been determined as transmitted by ticks, although it is suspected that spirillosis of fowls may occur and be thus transmitted in southwestern Texas. It has also been pointed out to the writer by Prof. H. A. Morgan that hunting dogs

taken from Louisiana to Cuba often sicken and die, possibly due to a disease transmitted by ticks.

That various parasites exist in the blood of animals, many of which are at present unknown, there can be no doubt, although the great activity along this line of investigation during the past few years has brought many to light.

The possibility that diseases which are transmitted through the agency of ticks may be introduced into this country must be considered. If such a disease as is suggested exists in Cuba, it might be introduced into this country with returning dogs. Prof. Lounsbury states that the malignant jaundice of dogs in South Africa and India has already been introduced into France and that it is likely to be introduced into this country. He states that should Angora goats be brought to this country from South Africa that they might bring heartwater which is so common on the veldts of that country. We trust, however, that the rigid inspection of animals entering this country by the U. S. Department of Agriculture, through the Bureau of Animal Industry, may prevent the introduction of such diseases.

While the scarcity of ticks in the colder sections might exclude the transmission of these diseases, yet in the warmer parts of our country, where the species and individual ticks are numerous, an intermediate tick host might readily adapt itself. It must be emphasized that the prevention of the importation of ticks is not sufficient. The danger is in animals, the blood of which is infectious, that may be attacked by native ticks.

The rapid development in our knowledge of the active agents in the transmission of diseases indicates the opportunities and possibilities that may result from a better knowledge of this group of parasites, and emphasizes the importance of a better acquaintance with the life history and habits of our North American ticks.

In this broad field of investigation it remains for the entomologist in this country to elucidate the biology of the ticks, as has been so ably done in South Africa by Lounsbury.

I have prepared the following table which shows graphically this relation of ticks to disease:

TABLE SHOWING THE RELATION OF TICKS TO DISEASE.

Disease				Tick concerned.	Infection		Molts	
Name	Host	Geography	Due to		Imbibed by	Transmitted by	First	Second
Splenetic Fever, Texas Fever, Red Water or Bovine Piroplasmosis	Cattle	North America	*Piroplasma bigeminum*	*Margaropus annulatus* Say	adult?	larva	on host	on host
	"	Australia	" "	" *australis* Fuller	" ?	"	" "	" "
	"	South Africa	" "	" *decoloratus* Koch	" ?	"	" "	" "
	"	South America	" "	" *micropla* Canst.	" ?	"	" "	" "
	"	Europe	" "	*Ixodes ricinus* Linn.	adult	larva, nymph	off "	off "
African Coast Fever, Rhodesian Cattle Disease or East Coast Fever	"	South Africa	" *parvum*	*Rhipicephalus appendiculatus* Neum.	larva nymph	nymph adult	" "	" "
				" *simus* Koch	nymph	adult	" "	" "
				" *nitens* Neum.	larva	nymph	" "	" "
				" *evertsi* Neum.	nymph	adult	on "	" "
				" *capensis* Koch	nymph	adult	off "	" "
Malignant Jaundice	Dog	South Africa	" *canis*	*Haemaphysalis leachi* Aud.	adult	adult (2nd gen.)	" "	" "
		Madras, India	" "	*Rhipicephalus sanguineus* Latr.				
Biliary Fever	Horses Mules Donkeys	South Africa	" *equi*	*Rhipicephalus evertsi* Neum.	nymph	adult	on "	" "
Carceag or Ovine Piroplasmosis	Sheep	Southern Europe	" *ovis*	" *bursa* Can. and Franz.	adult	adult (2d gen.)	" "	" "
Heartwater	Sheep Goats Cattle	South Africa	Unknown	*Amblyomma hebraeum* Koch	larva larva nymph	adult nymph adult	off "	on "
Rocky Mountain Spotted Fever	Man	North America (United States)	"	*Dermacentor occidentalis* Neum.	larva nymph	nymph adult	" "	off "
Brazilian Septicaemia, Spirillosis	Fowls	South America Soudan, Africa	*Spirochaete gallinarum*	*Argas miniatus* Koch	....	....	" "	" "
Spirillosis	Cattle	Transvaal	*Spirochaete theileri*	*Margaropus decoloratus* Koch	....	....	on "	on "
Human Tick Fever	Man	Central Africa	" *duttoni*	*Ornithodoros savignyi var caecus* Neum. (*moubata*)	adult adult	adult larva	off "	off "

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The eighth annual meeting of the Louisiana Society of Naturalists was held at New Orleans, February 1st. This Society is well known to scientific workers, especially those engaged in research work in the strictly biological sciences, who are located in the Southern States. The Society has a membership of over seventy, many of the members being connected with agricultural experiment stations or with leading educational institutions of the South. The Society's field is a broad one and among its publications are found meritorious papers upon botany, bacteriology, ornithology, animal physiology and invertebrate zoölogy, as well as a considerable number of papers upon various entomological subjects.

On the program was noted the following papers which are of interest to economic entomologists: "Notes upon the Life History and Habits of the Argentine Ant."—Wilmon Newell. "A short account of the Egg and Larva of a Psychodid."—B. H. Guilbeau. "The Relation of Entomology to Agriculture."—Arthur H. Rosenfeld. "Notes on the sugar cane pou-a-pouche."—J. B. Garret.

Mr. B. H. Guilbeau of Baton Rouge is President and Mr. R. S. Cocks, of Baton Rouge, is Secretary of the Society.